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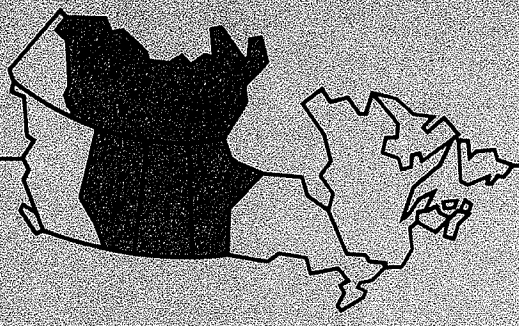
# Bibliography of lodgepole pine literature

H. Grewal, editor



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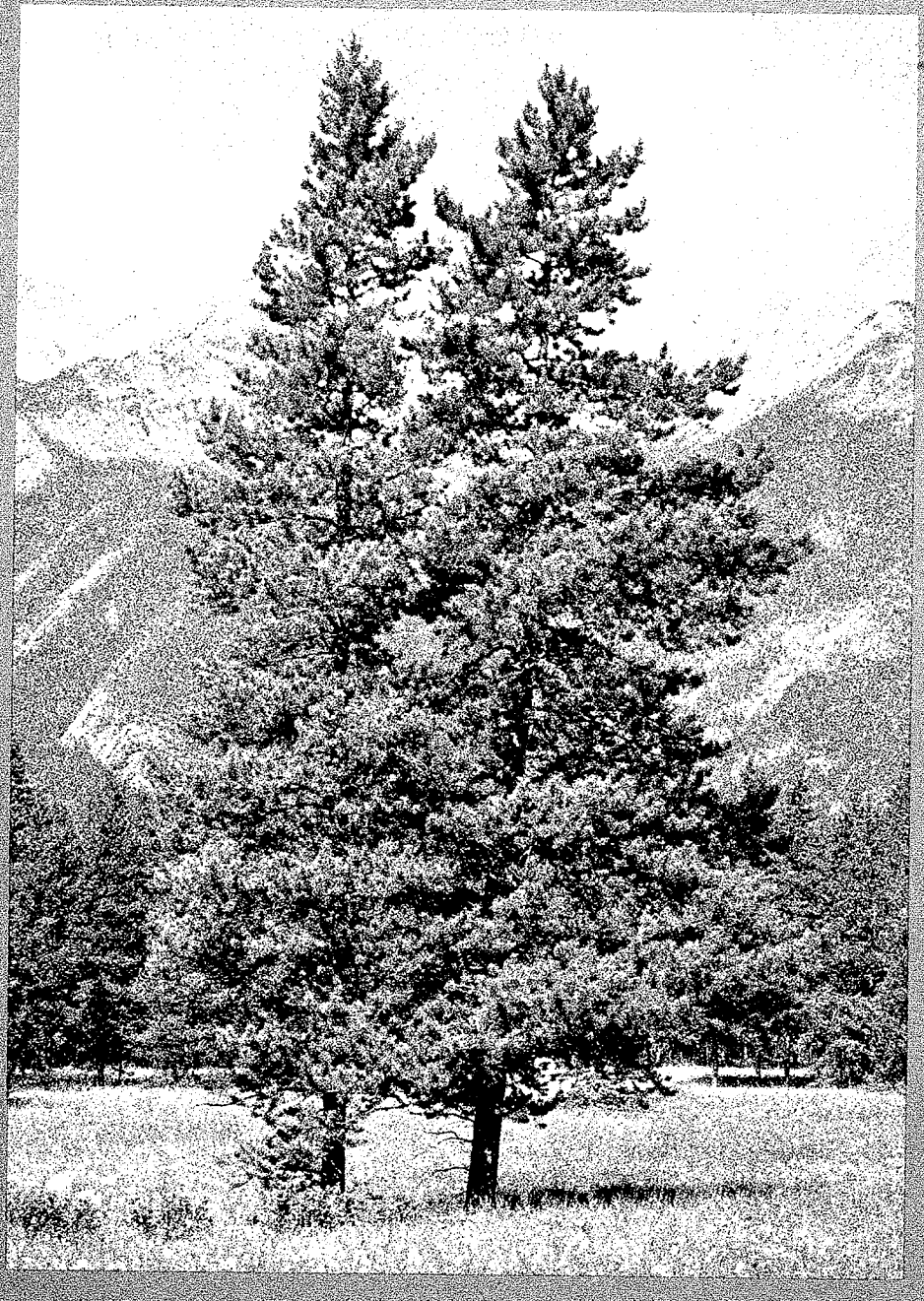

# BIBLIOGRAPHY OF LODGEPOLE PINE LITERATURE

*H. Grewal, editor*

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## ABSTRACT

An annotated bibliography of lodgepole pine (*Pinus contorta* Dougl.) literature, containing 1 418 entries arranged in alphabetical order by subject group, is presented. An authors' cross-reference index is also provided.

## RESUME

On présente une bibliographie annotée couvrant 1 418 pièces de littérature sur le pin lodgepole (*Pinus contorta* Dougl.), arrangées par ordre alphabétique selon le sujet. Un index par auteur est aussi inclus.

# CONTENTS

## INTRODUCTION

In 1983, Reid, Collins and Associates Limited of Vancouver prepared under contract with Supply and Services Canada a bibliography search of lodgepole pine (*Pinus contorta* Dougl.). This report is an update of the 1983 work; it includes numerous significant papers and reports published on the species since that time.

The added literature came from two main sources: assessment of CAB and BIOSIS data bases through the CAN/SDI (Canadian Selective Dissemination of Information) Library of Agriculture Canada in Ottawa, and the proceedings of the 1984 symposium, *Lodgepole pine—the species and its management*, held in Spokane, Washington, and repeated in Vancouver, B.C. (1985). The following search criteria were used in the data base assessments: English language; North American context; and the keywords lodgepole pine and *Pinus contorta*.

Classification of the literature follows the system set up by Reid, Collins and Associates (1983).

## ACKNOWLEDGMENTS

The editor thanks Dr. H. Cerezke, Dr. Y. Hiratsuka, and other researchers at the Northern Forestry Centre for reviewing the bibliography listings. The editor is also grateful to A. Irwin for help in writing computer programs necessary to prepare this bibliography.

## REFERENCES

Baumgartner, D.M.; Krebill, R.G.; Arnott, J.T.; Weetman, G.F., editors. 1985. Lodgepole pine: the species and its management. Off. Conf. Inst., Coop. Ext., Washington State Univ., Pullman, Washington.

Reid, Collins and Associates Ltd. 1983. Lodgepole pine literature search. Contract # 01SG-KH-505-2-0140. Dep. Supply Serv., Edmonton, Alberta.

# LODGEPOLE PINE LITERATURE SEARCH

## G E N E R A L

1. **ANON.** Pinus contorta as an exotic species. Proceedings of the IUFRO Working Party Meeting 1980 on Pinus contorta Provenances (S2-02-06) in Norway and Sweden. Swedish University of Agric. Sciences, Res. Note No. 30, 1981: 353 pp.
Subject Codes: N/A
RCA: X1079

Contains 24 papers presented by participants from Canada, Denmark, Finland, Fed. Republic of Germany, Great Britain, Ireland, Norway, Sweden and the U.S.A. The eight sessions covered: Pinus contorta in its native environments; survival, height increment and growth rhythm; volume increment; quality, including wood density; stability against wind and snow; diseases, insect pests and other damage; seed production and breeding beyond the provenance level.

2. **ANON.** Contortatallen-vart tredje barrtrad? (Lodgepole pine-our third conifer?) Skogshogskolans hostkonferens 1981, Sveriges Skogsvardsforbunds Tidskrift - Specialnummer Nr 1-2/-82, 1982: 152 pp.
Languages: sv
Summary Languages: en
Subject Codes: N/A
RCA: X1023

These proceedings present 21 papers all with English summaries describing lodgepole pine in terms of range, growth and yield, soil influences, damage, reforestation, provenance and management.

3. ALEXANDER, R.R. Silviculture of central and southern Rocky Mountain forests: a summary of the status of our knowledge by timber types.
USDA FOR. Serv. Research Paper, Rocky Mountain For. and Range Exp. Stn., 1974: No. RM-120: 36 pp.
4 ref.
Subject Codes: N/A
CAB: 409280

Summarizes four comprehensive reports, on the important forest types of the central and southern Rocky Mountain region. Includes what is known (about habitat conditions, successional relations, stand conditions, damaging agents, natural regeneration and early survival, site quality and growth and yield), what can be recommended (for 'regeneration silviculture' in even-aged and uneven-aged stands and 'multiple-use silviculture'), and what additional information is needed, for each forest type, viz. spruce/fir, lodgepole pine, south-western mixed conifers (including aspen), south- western ponderosa pine, and Black Hills ponderosa pine.

4. DIETRICHSON, J. Pinus contorta can increase both short- and long-term yields in Norway.
Norsk Skogbruk, 1974, 20(11): 7, 9-11
3 ref.
Language: no
Subject Codes: N/A
CAB: 390756

Briefly discusses present experience of P. contorta in Scandinavia, including unpublished research results on site requirements, growth and yield, silviculture, genetic variability, timber quality, biotic and abiotic injuries etc. It is concluded that P. contorta is highly promising in certain parts of Norway, that it can be grown to maturity without thinning, and that, because it matures faster than Scots Pine, it may help to mitigate the shortage of mature timber expected in 15-30 years' time.

5. **DINGLE**, R.W. Lodgepole pine - Pinus-contorta.
Wash. Agr. Exp. Sta. Bulletin (707), 1968: 36
Subject Codes: 2.0
BIO: 69079102

6. FOWELLS, H.A. Lodgepole pine (Pinus contorta Dougl.) IN: Silvics of Forest Trees of the United States.
Agriculture Handbook No. 271, USDA, 1965: 373-383
82 ref
Subject Codes: N/A
RCA: X1011

7. FRANKLIN, J.F. Major vegetation types of Oregon, USA and Washington, USA. IN: Abstracts of the Papers Presented at the XI International Botanical Congress and the International Wood Chemistry Symposium, 260 pp.
XI Botanical Congress, Seattle, WA, USA, 1969: 63
Subject Codes: N A
BIO: 69081391

8. GRANT, M.C., KNOWLES, P. Patterns or age size and survivorship in 4 Colorado, USA conifers.
The Univ. of B.C. 2nd Intn'l. Congress of Systematic & Evolutional Biology, Vancouver, B.C., July 17-24, 1980. I+441 pp. Paper, 0(0), 1980: 217
Subject Codes: N/A
BIO: 22000820

9. HEIKURAINEN, L., MALCOLM, D.C., et al The proceedings of the 4th International Peat Congress, Otaniemi, Finland, June 25-30, 1972. Vol. 1-4
Helsinki, Finland, Turveteollisuuslitto ry., Aleksanterink, 48 B., 1972: 484 + 303 + 569 + 353 pp.
many ref.
Subject Codes: N/A
CAB: 098209

Vol. 1 contains 40 papers on the survey, classification, study and conservation of peatlands, and on terminology, notation and standardization. Vol. 2 contains 32 papers on geotechnics and the winning, harvesting, storage, transportation and processing of peat and sapropel for industrial, agricultural and horticultural purposes. Vol. 3 contains 49 papers on bog cultivation and afforestation, and the use of peat in agriculture and horticulture. Vol. 4 contains 34 papers on peat chemistry and physics. The papers in Vol. 3 on the utilization of peatlands for forestry include: Nutrient contents of peat soils in Newfoundland (F.C. Pollett); The effect of fertilization on throughfall and ground water table in peatlands drained for forestry (J. Paivanen); Estimation of the effect of fertilizer application to peatland drained for forestry (K. Seppala); Effect of soil preparation and fertilization on the growth of young pine plantations on peat (S. Kaunisto); Early effects of different types, rates and methods of application of phosphate rock on peatland (J.M. Mackenzie) (describes trials on Pinus contorta and Picea sitchensis in N. England and Scotland); The possibility of using peat in the fertilization of young forest plantations on dune sands (B. Janiszewski); and Reforestation with tree seedlings grown in extruded peat cylinders. Part III. Evaluation of conifer planting trials (D.L. Mitchell; W.C. Kay) (describes trials in Canada with Pinus contorta and Picea glauca).

10. HEIKURAINEN, L., et al Proceedings of the 5th International Peat Congress, Poznan, Poland, Sept. 21-25, 1976: Vol. 1-3
Warsaw, Poland, Wydawnictwa Czasopism Technicznych Not., 1976, 482 + 326 + 335 pp.
many ref.
Subject Codes: N/A
CAB: 892240

Vol. 1 contains 45 papers on the role of peat and peatlands in the protection of the natural environment, including: Heikurainen, L. Comparison between runoff conditions on a virgin peatland and a forest drainage area. Vol. 2 contains 32 papers on the formation, physical and chemical properties of peat and peatlands,

including: Moose, P.D.; Wilmott, A. Prehistoric forest clearance and the development of peatlands in the uplands and lowlands of Britain. Vol. 3 contains 32 papers on the utilization of peat and peatlands in agriculture, horticulture, forestry and industry, including: Kapustinskaite, T. Forest stands on peat soils. Ushakov, Y. Modern methods and ways of afforestation on the exhausted and drained peat-bogs in the state forests of the Russian federation. Dillon, J.; Carey, M.L.; O'Carroll, N. The establishment and growth of coniferous tree species on blanket peat in the west of Ireland. Mainly Picea sitchensis and Pinus contorta. Seppala, K.; Westmand, C.J. Results of some fertilization experiments in drained peatland forests in north-eastern Finland. NPK treatment of spruce (Picea abies) and pine (Pinus sylvestris) forests. Mannerkoski, H. Effect of water table fluctuations on the growth of Betula verrocosa (B. pendula) and Pinus sylvestris seedlings on a peat substrate.

11. HOSIE, R.C. Lodgepole pine. IN: Native Trees of Canada.
Canadian Forestry Service, Dept. of the Environment, 1973: 52-53
RCA: X1145

12. MACDONALD, J., WOOD, R.F., et al. Pinus contorta. In: Exotic Forest Trees in Great Britain.
Paper prepared for the 7th British Commonwealth Forestry Conference, Australia and New Zealand. Forestry Comission Bulletin No. 30 1957: 94-100
Subject Codes: N/A
RCA: X1006

13. MANUWAL, D.A. Lodgepole pine, larch, Douglas-fir montane forest.
Audubon Field Notes, 22(6), 1968: 724
Subject Codes: N/A
BIO: 70025996

14. MIROV, N.T. The genus pinus.
The Ronald Press Company, New York, 1967: 602 pp.
Subject Codes: N/A
RCA: X1013

15. SMITHERS, L.A. Lodgepole pine in Alberta.
Can. Dept. of forestry, Bulletin 127, 1961: 153 pp.
Subject Codes: N/A
RCA: X1032

16. TOLSTRUP, E. A forestry study tour to Ireland.
Dan. Skovforen. Tidskr., 1977, 62(3): 207-219
Language: da
Summary Languages: en
Subject Codes: N/A
LISC: 023602

In June 1976, the author made a study tour on forestry to Eire. Irish forestry is characterized by the large afforestations carried out after World War II. The forest area increased from 90000 ha in 1942 to 350000 ha in 1974 (the aim is 500000 ha of forest). The species dominating the afforestations are Picea sitchensis and Pinus contorta. Forest administration, recreation facilities in the forests, wildlife/conservation, and foresty education are topics discussed in the article. The author also comments on future problems for silviculture and the sale of forest products.

17. VON WEISSENBERG, K. Experiences of lodgepole pine in Finland.
Iisvesi, Finland, Suonenjoki Forest Experiment Station, 1972, 73 pp.
21 ref.
Subject Codes: 7.4.3
CAB: 122076

Paper presented at the meeting of the Nordic Working Group on Provenance Research

and Seed Procurement, 1972. Presents a general survey of Pinus contorta in Finland, giving: descriptions of existing plantations; numerical data on growth and yield; results of provenance trials; information on seed production and breeding; damage caused by biotic and abiotic factors; and some general conclusions and recommendations.

18. WOOD, R.F. Studies of north-west american forests in relation to silviculture in Great Britain.
Bull. For. Comm. No. 25, 1955
Subject Codes: N/A
RCA: X1007

1.0 S P E C I E S D E S C R I P T I O N

19. PFISTER, R.D., MCDONALD, P.M. Lodgepole pine. IN: Forest Cover Types of the United States and Canada.
Society of American Foresters, Washington, D.C., 1980: 97-98
Subject Codes: N/A
RCA: X1201

1.1 NOMENCLATURE

20. HOFFMANN, G.R., ALEXANDER, R.R. Forest vegetation of the Routt National Forest in northwestern Colorado: a habitat type classification.
Res. Paper, Rocky Mountain For. and Range Exp. Stn., 1980, RM-221: 41 pp.
Subject Codes: 3.6
LISC: 562407

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 11 forest habitat types. Included were 5 habitat types in the Populus tremuloides series, 2 in the Abies lasiocarpa series, and one each in Pinus contorta, Pseudotsuga menziesii, Pinus flexilis, and Quercus gambelii series. A key to identify the habitat types and the management implications associated with each are provided.

21. LA ROI, G.H., HNATIUK, R.J. The Pinus-contorta forests of Banff and Jasper National Parks, Canada: A study in comparative synecology and syntaxonomy.
Ecol. Monogr., 50(1), 1980: 30 pp.
Subject Codes: 3.0
BIO: 70070425

P. contorta Dougl. (lodgepole pine) is the most important seral tree species in the Canadian Rocky Mountains, forming a complex mosaic of even- and several aged-forests of fire origin over a wide range of elevations and habitats. East of the Continental Divide in Alberta it is the most abundant tree of montane and lower subalpine forests, due to extensive and frequent wildfires before 1910. Sixty-three mature, undisturbed P. contorta forest stands were surveyed for physiognomy, vascular floristic composition, species cover, age structure and physical site properties. A direct gradient ordination of stands was constructed using elevation corrected to 53 degree N as the 1st axis, and synthetic moisture index derived from moisture indicator values of species as the 2nd axis. Stands were classified using minimum-variance cluster analysis with species cover data, error-sum-of squares association analysis with species presence-absence data, and dominance analysis based on the leading species of shrub and herb-dwarf shrub strata. Vascular species richness per stand averaged 38. Species occurring in a significantly higher percentage of stands in one national park than the other were more numerous in Banff than Jasper. Most stands were 100 yr old. Prevailing soils were Eluviated Eutric Brunisols and Orthic Eutric Brunisols. Both vascular species and community classification (syntaxonomic) units showed ecologically meaningful distribution and abundance patterns on the ordination. Though based on different criteria, the 4 classifications were quite similar, permitting synthesis of 5 P. contorta community types (CT), these forming an ecocline from low-elevation dry to high-elevation moist: P. contorta/Shepherdia canadensis/Arctostaphylos uva-ursi (Pico/Shca/Aruv), P. contorta/S.

canadensis/Elymus innovatus (Pico/Shca/Elin), P. contorta/Alnus crispa/Linnaea borealis (Pico/Alcr/Libo), P. contorta/menziesii glabella/Vaccinium scoparium (Pinco/Megl/Vasc), P. contorta/Ledum groenlandicum/V. Scoparium (Pico/Legr/Vasc). Stands of Pico/Shca/Aruv are mostly seral to Pseudotsuga menziesii, of Pico/Shca/Elin to either Picea glauca or Pseudotsuga menziesii, of Pico/Alcr/Libo to P. glauca-Abies lasiocarpa, of Pico/Megl/Vasc to Picea engelmanni- A. lasiocarpa, and of Pico/Legr/Vasc mostly to Picea mariana. P. contorta may be climax on dry, oligotrophic sites above the cold elevational limit of pseudotsuga. A stable species structure (dominance hierarchy) develops in subordinate vascular strata of seral P. contorta forests long before the pine is replaced by climax tree species. The P. contorta forests of Banff and Jasper are compared with those of adjoining regions in Alberta, British Columbia and Montana (USA).

22. NEWMAN, K.W. The concept of overlap for evaluating linkage distance as used for clustering.
Taxon, 31(2), 1982: 266-276
Subject Codes: 1.5, 3.0
BIO: 74084112

A procedure (of interest in taxonomy and ecology) was described for evaluating linkage between objects which are represented by points in a multi-dimensional space in terms of overlap between replicates. An illustration of the procedure (geographic range of Pinus contorta) demonstrated its usefulness for the recognition and analysis of innate group structure.

23. PFISTER, R.D. Forest ecosystem description, classification and management in northern Rocky Mountains and intermountain regions.
Project INT-1205, Forestry Sciences Lab., Missoula, MON, 12 May 65 to 30 Sep 81
Subject Codes: 3.0, 8.0
CRIS: 0000093

Objectives: Develop a comprehensive ecological framework for identification, development and maintenance of forest ecosystems, and provide guides for avoiding or overcoming critical management problems. Approach: Complete development of a habitat type classification system for forest lands in the Intermountain Station area. This will be accomplished through several cooperative studies wherein this research work unit will provide leadership in concepts, methodology, development of taxonomic classifications, mapping techniques and guides for proper use of classification systems. Develop classifications and models for secondary plant succession within the major forest habitat types. This will be accomplished by developing new approaches to classification and modeling appropriate to multifunctional user needs. Integrate existing ecological knowledge by habitat types for use as management implications. This research work unit will provide methodology for synthesis of existing knowledge and leadership for cooperative studies with other research units. Progress: (80/10 81/09) A forest habitat type classification, based on potential natural vegetation, was published for all the forest lands of central Idaho. Comprehensive new knowledge on forest vegetation, management, land capability and environments is provided in a hierarchical framework. Most land managers and managers and scientists in central Idaho are using the classification for site identification, mapping, land-use planning, project activities, and extrapolation of research results. Mountain and forest successional modeling approaches were completed. Together, they provide a foundation for development of new and improved techniques for classifying and modeling secondary plant succession as a natural process and as influenced by management actions. Management implications related to habitat type classification were summarized for watershed management and general silviculture. These new summaries of existing knowledge provide practical management information, identify knowledge gaps, and provide suggestions of future research needs and approaches. Research leadership was provided to develop and help implement a formal research natural area program for the Northern Region (USDA Forest Service).

## 1.2 MORPHOLOGY

24. FORREST, G.I. Monoterpene variation in lodgepole pine (Pinus contorta) and Scots pine (P. sylvestris). In: Proceedings of the Conference on Biochemical Genetics

of Forest Trees, Umea, Sweden, 1978.
Sveriges Lantbruksuniversitet, 1979, 1: 136-150
Subject Codes: 5.4
CAB: 1556986

25. FORREST, G.I. Variation in monoterpene composition of the shoot cortical oleo resin within and between trees of Pinus contorta.
Biochem. Syst. Ecol., 8(4), 1980: 337-342
Subject Codes: N/A
BIO: 72051848

Ten young lodgepole pine trees were studied for variation in monoterpene composition of the shoot cortical oleoresin due to position within the crown. There was no significant difference between whorls, but small differences occurred between the lateral and terminal shoots of branches. The nature of the differences varied between trees; 3-carene showed the most consistent positional difference.

26. FORREST, G.I. Geographical variation in the monoterpenes of Pinus contorta oleo resin.
Biochem. Syst. Ecol., 8(4), 1980: 343-360
Subject Codes: N/A
BIO: 72050151

The monoterpene composition of the shoot cortical oleoresin allowed the natural range of Lodgepole pine (P. contorta) to be divided into chemically distinct regions. The trees examined were all grown in Britain (UK) from seed originally collected from 150 localities in northwest North America. Those from the central area of the natural range contained a wide variety of monoterpene pattern-types, while those from more peripheral areas were more exclusively characterized by their own specific pattern- types. Chemical evidence for introgresion with Jack pine (P. banksiana) was detected in trees originating from central British Columbia and there was also a highly localized and pronounced region of introgression chemotypes in coastal populations near the border or Oregon and California. Variations between trees grown in replicate plots and at different sites in Britain were small, and the results indicated that resin analysis of 25 trees was usually sufficient to determine the region of origin of an unknown population.

27. HO, R.H., OWENS, J.N. Microstrobili of Lodgepole Pine.
Canadian Journal of Forest Research, 1973, 3(3): 453-456
Subject Codes: N/A
CAB: 234745

A morphological study of 3 trees of Pinus contorta, with special reference to the variation in the numbers of microsporangia per shoot, bud scales, microsporophylls and pollen grains.

28. HO, R.H., OWENS, J.N. Microsporogenesis and pollen formation in lodgepole pine.
Canadian Journal of Botany, 1974, 52(7): 1669-1674
22 ref. + 3 pl.
Subject Codes: 2.8
CAB: 409177

Reports a study of three coastal and two inland trees of Pinus contorta, including a description of microstrobili in the inland trees; a morphological study of microstrobili in the coastal trees has already been noticed.

29. MANNING, T.D.R., HEMMINGSON, J.A. Bark and oleo resin monoterpene hydrocarbons of Pinus-contorta grown in New Zealand.
New Zealand J. Sci., 18(1), 1975: 115-118
Subject Codes: N/A
BIO: 60054408

30. MAYER, K.E., FOX, L. III Identification of conifer species groupings from Landsat

digital classifications.
Photogrammetric Engineering and Remote Sensing, 1981, 48(11): 1607-1614
12 ref.
Subject Codes: 8.4
CAB: 1472422

Landsat digital data were obtained on Aug. 1, 1978 for an area of the Shasta-Trinity National Forest (mostly mixed and pure conifer stands) in California and processed using guided and unsupervised clustering techniques. The guided method used 100 homogenous timber resource training fields representing 4 species groupings ((a) mixed conifers; (b) ponderosa, sugar and western white pines, Pinus ponderosa, P. lambertiana and P. monticola; (c) white, red and Douglas-firs, Abies concolor, A. magnifica, Pseudotsuga menziesii; and (d) lodgepole pine, Pinus contorta), two size classes and 2 density categories. Spectral classes not developed by this method were produced by unsupervised clustering of data for the whole area and the two sets of classes merged to give a total of 38. Spectral curves were developed from the mean digital numbers of each spectral class and curve shapes from a known resource category were used to identify unknown shapes. The results were compared with US Forest Service aerial colour photographs (1:15 840 taken in July, 1975), and showed an overall classification accuracy of 0.83 for species groups, canopy density classes and crown diam. categories.

31. OSTROLUCKA, M.G., POSPISIL, J. Amino acid composition of the pollen of Salix and Pinus.
Acta Dendrobiologica, 1978/79, 1(2): 361, 363-389
49 ref.
Language: Sk
Summary Languages: ru, en, de
Subject Codes: N/A
CAB: 1556879

The contents of 15 free and 16 bound amino acids were determined by paper chromatography in the pollen of 10-13 species of Salix (1-9 clones of each) and in Pinus banksiana, P. contorta, P. mugo and P. sylvestris. The range of total amino acid contents was 202-291 mg/g in Salix and 78-94 mg/g in Pinus. The qualitative composition of the amino acids was generally similar in the 2 genera, with some minor exceptions. The greatest interspecific variation was in the free amino acids.

## 1.3 ANATOMY

32. BAGNELL, C.R. JR. Species distinction among pollen grains of Abies, Picea and Pinus in the Rocky Mountain area (a scanning electron microscope study).
Review of Palaeobotany and Palynology, 1975, 19(3): 203-220
22 ref.
Subject Codes: 1.2
CAB: 903592

33. FRANCE, R.C., MEXAL, J.G. Morphological variation of tracheids in the bolewood of mature Picea engelmannii and Pinus contorta.
Canadian Journal of Forest Research, 1980, 10(4): 573-578
24 ref.
Language: en
Summary Language: fr
Subject Codes: 2.10
CAB: 1329573

Variations in tracheid morphology with changes in tree ht. were examined. Fibre length, radial and tangential lumen diam., lumen area, the ratio lumen diam./cell diam. and pit pore size of Engelmann spruce increased with increasing ht. to mid-bole, then decreased with further increases in ht. The force required to collapse the cells decreased to a minimum at mid-bole and then increased to the top of the tree. From authors' summary.

34. MARK, W.R., CREWS, D.L. Heat-pulse velocity and bordered pit condition in living engelmann spruce and lodgepole pine trees.
Forest Science, 1973, 19(4): 291-294
8 ref.
Subject Codes: 2.10
CAB: 257232

In a mixed stand in Colorado, two Pinus contorta trees (of d.b.h. 24.6 and 27.4 cm) and two Picea engelmannii trees (of d.b.h. 31.2 and 40.6 cm) were studied to relate sap movement and wood structure. In the vicinity of the cambium, where bordered pits were immature and almost imperforate, sap flow was slow; maximum flow was measured deeper in the tree, 30-42 cm from the cambium, where pits were not aspirated, and were only partly encrusted; and flow decreased again with increasing distance from the cambium, where pits showed a high frequency of aspiration, or were almost completely encrusted.

35. ROTHWELL, R.L. Sapwood water content of Lodgepole Pine.
Dissertation Abstracts International, B, 1976, 36(7): 3151
Subject Codes: 2.10
CAB: 630783

Fluctuations in the water content of sapwood at b.h. in Pinus contorta var. latifolia were related to the area of conducting xylem and to environmental and plant variables. Results indicated a conducting xylem of 3.25 cm width from the cambium, i.e. 60-80% of the total cross-sectional area in the trees studied. Multiple regression analyses indicated a significant correlation between sapwood water content and environmental and plant variables. The most important group of variables included soil water content, heat-pulse velocity and precipitation. Laboratory tests indicated that attenuation of gamma-radiation was a feasible method for measuring the water content of wood. In the field, measurements in situ obtained by the gamma-radiation or the gravimetric methods showed similar monthly and diurnal fluctuations, though values obtained by the gamma-radiation method were significantly greater than those obtained by gravimetric methods.

36. TAYLOR, F.W. Wood anatomy studies.
Project MIS-0698, Mississippi State Univ., Mississippi State, MIS., 01 Oct 80 to 30 Sept 83
Subject Codes: 7.7, 7.9
CRIS: 0082198

Objectives: Evaluate the effect of high pruning and wide spacing to produce rapidly grown sawlogs on the properties of wood; see if intrusive growth of primary walls of cells during differentiation results in more or less variation of cell length in species with storied cambiums; evaluate the effect of variations in thickness of tracheids within latewood differentiation zones; determine the extent of variation and/or discover patterns in cambial activity and cellular differentiation from growth increment to growth increment and within increments and develop a better understanding of the movement of liquids through hardwood structure. Approach: Basic wood properties and their variation will be determined by measurements on breast-height increment cores. The length of elements, particularly vessels and fibers, will be measured by an unbiased method for both juvenile and mature wood of each species. Cross sections of loblolly pine trees grown on sites with a well documented environmental history will be examined microscopically to identify rings with variable wall thickness zones. Measurements will be made along severe radii of pine cross sections. Liquid monomers of varying viscosity will be used to penetrate vessels. Progress: Studies of the effect of accelerated growth rate, due to wide spacing and repeated thinning, on basic wood properties of loblolly is complete. During some growth periods, radial growth of test trees was almost three times as great as radial growth of control trees. During the last 10 years of the study (mature wood zone), growth rate differences between treated and control trees were not great and there were no significant differences in latewood percentage or tracheid length. Specific gravity was not significantly influenced by growth rate differences in any growth zone. The conclusion is that trees can be rapidly grown without affecting specific gravity. Studies on the variation of wood properties of species growing in the normal forests of North America have been submitted for publication. Investigation of properties of species with storied cambiums, and studies of the exterior morphology of vessels are continuing.

37. TEOH, S.B., REES, H. Nuclear DNA amounts in population of Picea and Pinus

species.
Heredity, 1976, 36(1): 123-137
22 ref.
Subject Codes: N/A
CAB: 612474

Estimates of nuclear DNA content in root tips of Picea glauca from 26 sources, covering almost its entire range in North America, showed no significant variation in DNA content within the species except for minor fluctuations due to B chromosomes. There was no significant variation in the chromosome volume or nuclear size between and within material from different sources. There were no detectable differences in nuclear DNA content between Picea glauca and Picea engelmannii, and in Pinus contorta, as in Pinus glauca, nuclear size and DNA contents did not vary significantly between or within material from different sources.

38. WODZICKI, T.J., BROWN, C.L. Cellular differentiation of the cambium in the Pinaceae.
Botanical Gazette, 1973, 134(2): 139-146
13 ref.
Subject Codes: N/A
CAB: 257722

Describes patterns of cellular differentiation in the cambial zone of stem segments of Abies balsamea, Cedrus deodara, Larix decidua, Pinus contorta, P. echinata, P. sylvestris, Pseudotsuga menziesii and Tsuga canadensis (aged 8-45 years), with particular attention to the cambial ray initials. The initials consist of erect and radially elongate cells, the latter often extending across the zone of dividing axial elements and sometimes reaching the mature xylem and phloem. The continuity of the cambium is interupted in some genera (Picea, Larix and Pseudotsuga) by the radial continuity of open resin canals between the xylem and phloem.

## 1.4 VARIATION

39. ANON. Lulu Island as a provenance source of lodgepole pine.
Scottish Forestry, 23(1), 1969: 47-48
Subject Codes: 4.1
BIO: 70089465

40. ANON. Activities 1974.
Verksamheten, 1974, 32-45
Language: sv
Subject Codes: N/A
CAB: 476160

The report covers provenance trials, progeny testing and other investigational work mainly on Pinus sylvestris and Picea abies. Analysis of data on variation in volume weight ratios from old trials, plantations and collections of Pinus contorta has indicated that such variation is inherited as it is in P. sylvestris. Results from trials with spruce provenance crosses have shown that, in northern areas, those of continental or southern Swedish provenance may be faster growing than northern spruce. In central Sweden, hybrids between Swedish and central European spruce gave better average growth than material of either parental types.

41. ANON. Report on forest research for the year ended March 1974.
Forestry Commission, London, UK, 1974: 109 pp.
many ref.
Subject Codes: 5.4, 7.2
CAB: 560493

The Forestry Commissioners designated and established the Seed Testing Station at Alice Holt Lodge as the official seed testing station for silvicultural, propagating and plant material in the UK. Provenance trials in progress are

reported for Picea sitchensis, P. engelmannii, P. abies, Pinus contorta, Abies grandis and Alnus rubra. The resources of the forest genetics branch continue to be heavily deployed towards the improvement of P. sitchensis with Pinus contorta, P. sylvestris, P. nigra var. maritima and the larches also receiving attention. The progeny-testing programme has expanded steadily until more than 200 are now under test. In the spring of 1973 almost 500 intraspecific crosses were made by means of controlled pollinations among larches, Picea sitchensis, Pinus contorta and P. sylvestris. In tests on Picea sitchensis, vigour could be predicted from concentrations of leucoanthocyanins and two stilbenes in the young stems; the relationship was highly significant. In the same species preliminary gas-liquid chromatography investigation of terpene variation in the resin have shown this to be a rapid and simple method of distinguishing a tree within close limits. It is tentatively suggested that terpene analysis may allow individual trees to be assigned to relatively fine genetic categories and also be of value in the study of the genetics of given progeny lines and in monitoring the degree of genetic variability or heterozygosity within and between populations. In mature parts of the tree the monoterpene composition of the cortical resin was remarkably constant. When trees from eight sources were examined, trees from Vancouver Island, Canada, differed markedly from all others in terpene composition.

42. ANON. Pinus contorta provenance studies.
Research and Development paper,Forestry Commission, England, 1976
Subject Codes: N/A
RCA: X1004

43. ANON. Pine.
Metsanjalostussaatio: Foundation for forest tree breeding, 1977, Helsinki, Finland, 1978: 31 pp.
Language: Fi
Subject Codes: 5.4
CAB: 1071707

In a 6-year old provenance trial of Pinus contorta, 43 seed sources did better than the best local P. sylvestris control. Materials of Canadian provenance from British Columbia and Alberta approx. lat. 55 deg. N and 500-1200 m alt. was best suited to conditions in southern and central Finland.

44. ALDHOUS, J.R. Lodgepole pine seed zones with reference to British requirements.
IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 6-39
Subject Codes: N/A
CAB: 1118596

45. BARROS ASENJO, S. Development of 15 conifers introduced to Caramavida (Arauco Province).
Informe Tecnico, Instituto Forestal, 1978, No. 67: 31 pp.
15 ref.
Language: es
Summary Languages: en
Subject Codes: N/A
CAB: 1160875

Chile is seeking to broaden the range of species used in afforestation in order to lessen the potential impact of pest species. Trials of exotic conifer species have been planted on the western slope of the Nahuelbuta Range; survival and growth have been measured at 15 years. Full site data and details of planting stock are given. Of the species tested, Pinus radiata showed the best survival and growth but P. taeda, P. elliottii and Pseudotsuga menziesii are promising alternatives at similar sites.

46. BENECKE, U., MORRIS, N.J. Tree provenance trials. IN: Revegetation in the Rehabilitation of Mountain Lands.
FRI Symposium, New Zealand Forest Service, 1976, No. 16: 99-138
Subject Codes: 6.1
CAB: 1203557

Provenances of 7 species of conifer were grown at (a) 900 m and (b) 1320 m alt.

in the Craigieburn Range. Lodgepole pine (a coastal provenance from Karioi, New Zealand) grew best at all altitudes. Pinus uncinata from Ceillac, France, and P. mugo of Danish origin were the best provenances of mountain pine which grew well at both (a) and (b). Scots pine from the SW of its range was promising, but severe infestations of Eulachnus brevipilosus were a problem locally: Spanish provenances appeared less susceptible.

47. BORSET, O. Introduction of exotic trees and use of monocultures in boreal areas.
Ecol. Bull., 1976, 21: 103-106
Subject Codes: 8.6
LISC: 579097

Generally, the use of foreign spp plays a modest part in Norwegian forestry. However, in west Norway, Picea sitchensis has found great use, owing to its high yields. In certain areas these plantations already dominate the landscape. This may not be without adverse effects, for example, for recreation and nature conservation. Similarly, the extensive use of Pinus contorta in north Sweden will gradually create a new and unfamiliar forest type. So far, these plantations are healthy, but there is always an element of uncertainty associated with exotic spp. The unfavourable effects of extensive monocultures recorded in central European forestry will probably not assume the same proportions in Nordic coniferous forests, with their generally great local variations in site. Even spruce monocultures are usually interspersed with a natural element of broadleaves, breaking some of the monotony. Nevertheless, certain adverse effects of monocultures must be kept in mind, such as possible soil degradation, reduced variety, disasters resulting from attack by insects and fungi, the hazard of forest fire, and dull uniformity of the landscape.

48. BROOK, S.J. Exotic trees for high latitude Alaska, U.S.A. IN: Proceedings of the 32nd Alaska Science Meeting, Fairbanks, Alaska, U.S.A., Aug. 25-27, 1981.
Proc. Alaska Sci. Conf., 32(0), 1981: 144-145
Subject Codes: N/A
BIO: 23008038

49. CAHALAN, C.M. Provenance and clonal variation in growth, branching and phenology in Picea sitchensis and Pinus contorta.
Silvae Genetica, 1981, 20(2/3): 40-46
16 ref.
Language: en
Summary Languages: de
Subject Codes: 2.1, 5.4
CAB: 1539772

Four clones from 5 provenances of each of Picea sitchensis and Pinus contorta were grown from shoot cuttings taken from 15 and 14-year old trees respectively and planted at a lowland and an upland site in Scotland. Results after 5 years showed that provenances accounted for 25 to 72% of variation in height and diameter and clones within provenances for 9 to 31%. Repeatabilities of clone means for height and diameter were 0.84 and 0.76 respectively for P. sitchensis at the lowland site, predicting genetic gains of 38% and 30% over the mean by selecting the best 5% of clones within provenances. Corresponding repeatabilities for P. contorta were 0.54 and 0.58, predicting gains of 10% and 14%. Genetic gains from selection at the upland site were expected to be somewhat lower. From author's summary.

50. CANNELL, M.G.R. Production of branches and foliage by young trees of Pinus contorta and Picea sitchensis: provenance differences and their simulation.
Journal of Applied Ecology, 1974, 11(3): 1091-1115
66 ref. + 2 pl.
Subject Codes: 2.2
CAB: 502909

Measurements were made of the length and disposition of all branches on young trees of P. contorta (a) planted in Peeblesshire, Scotland, in 1966, and P. sitchensis (b) planted in Argyll, in 1968, from seed of various provenances from NW America with inherent differences in height and branching habit. Data for (a) were collected from 10 trees of each of 6 provenances plus one artificial hybrid during winer 1971-72, when the trees were 9 years old, and from 4 trees of each of 5 provenances of 8-year-old trees of (b) in 1972-73. The amounts of needle tissue and stemwood produced by the different provenances were not closely related to

differences in needle size or number per unit length of branch, but were strongly determined by up to three-fold differences in total length of needle-bearing shoot per tree. This in turn was controlled by (1) the amount of leader extension per year, and (2) the numbers of lateral branches produced. Results showed that S. coastal provenances of (a) and (b) grew consistently up to 35% and 100% taller respectively than N. and/or inland provenances; branch lengths showed corresponding variations. Among provenances of one species there were no appreciable differences either in "apical control", which defined the length of lateral branches relative to terminal shoot. The numbers of laterals borne by leaders and first-, second- and third-order branches were proportional to their lengths. Numbers ranged from 0.35 per cm in many coastal provenances of (a) to 0.25 per cm in inland or heavily flowering provenances, while in (b) numbers varied unpredictably among provenances from 0.85 to 0.60 per cm. However, these differences did not necessarily correspond to differences in total branch numbers, as these depended also on the lengths of the shoots, determined ultimately by leader growth. A model based on measurements of shoot lengths and branch-number/parent- shoot-length relations, showed how the numbers and total length of branches multiplied as a consequence of greater leader growth. It was thereby confirmed that some provenances branched more profusely than others simply because they grew more rapidly, and that phenotypes differing in height growth could mimic such provenance differences as occurred, e.g. between some N. and S. coastal provenances of (a). By contrast, inland provenances of (a) and the hybrid were inherently sparsely branched, as were some provenances of (b).

51. CRITCHFIELD, W.B. Hybridization and the evolution of forest trees.
Project PSW-1499-P10, Pacific SW Forest and Range Exp. Sta., Berkeley, CAL, 24 Aug 71 to 24 Aug 84
Subject Codes: 5.4
CRIS: 0022110

Objectives: Gain a better understanding of the evolutionary importance of genetic interactions between forest tree species by assessing the impact of natural hybridization and introgression on their genetic architecture. Approach: Survey incidence and extent of hybrid interactions between tree species in "suture zones". Emphasis on natural selection action in influencing movement and identity of characteristics among species and hybrids. Examine diffuse pattern of hybridization which has little apparent impact on participant species. Determine what factors prevent spread of genetic mixing and whether selection acts differentially on hybrids and non-hybrids during different stages of life cycle. Examine nature and organization of isolating barriers that tend to keep species distinct. Emphasis will be on genetic mechanisms that restrict or prevent production of hybrids, the fate of these mechanisms in hybrid swarms, simulation of crossing under nature conditions, and the possibility of increased inviability of hybrids in advanced generations. Progress: 80/10 81/09 Lodgepole pine (Pinus contorta) is the most wide-ranging American pine, dominating the forests on about 65 million acres of western North America. In the U.S. it has evolved several highly differentiated but interfertile geographic and edaphic races. In Canada, where nearly all populations are descended from postglacial immigrants, geographic differentiation is less pronounced but some populations have been influenced by introgression from jack pine (P. banksiana). A few putative hybrids of Austrian and red pines (Pinus nigra, P. resinosa), long accepted as bona fide, have been shown by isozyme analysis to be hybrids between Austrian pine and some other, still unidentified species. This revised identification forecloses the possibility of using these hybrids as a bridge for the transfer of genes from other species into the genetically uniform red pine.

52. DANCIK, B.P. Enzyme variation among Alberta, Canada populations of jack pine Pinus-banksiana and lodgepole pine Pinus-contorta. IN: 1981 Meetings of the Genetics Society of America and the Genetic Society of Canada, Raleigh, N.C. USA. June 15-17, 1981, Genetics 97 (1 suppl.), 1981: S28-S29
Subject Codes: N/A
BIO: 22013535

53. DIETRICHSON, J. Geographic variation in Pinus-contorta - a study aiming at the use of the species in Norway.
Medd. Nor. Skogforsoksves, 28(2), 1970: 115-140
Subject Codes: N/A
BIO: 54037010

54. DIETRICHSON, J. A summary of studies on genetic variation in forest trees grown in Scandinavia with special reference to the adaptation problem.
Medd. Nor. Skogforsoksves, 29(1), 1971: 21-59
Subject Codes: N/A
BIO: 53019442

55. DIETRICHSON, J. Norwegian experiments with Pinus contorta. IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 74
1 ref.
Subject Codes: N/A
CAB: 1118602

56. DIETRICHSON, J., et al Provenances, Congress Group 2. IN: Proceedings, Div. II (Forest pl Norway, June 20 to July 2, 1976.
As, Norway, IUFRO, 1976: 126-214
Language: en,de
Summary Languages: de, en, fr
Subject Codes: N/A
CAB: 892234

Dietrichson, J., Krutzsch, P. Present status of European IUFRO 1938 provenance trials on Norway spruce (Picea abies (L.) Karst.). Shelbourne, C.J.A., Miller, J.T. Provenance variation in Pinus contorta - 6-year results from IUFRO seedlots in New Zealand. Fletcher, A.M. Seed collection in north west America with particular reference to Sitka spruce provenance studies. 14 reports on IUFRO "international ten provenance" trials with Sitka spruce in Ireland (O'Driscoll, J.). Belgium (Nanson, A.), British Columbia, Canada (Illingworth, K., Yeh, F.), Denmark (Kjersgard, O.), France (Birot, Y.), West Germany (Kleinschmit, J., Sauer, A.), Great Britain, North (Lewis, A.R., Lines, R.), Great Britain, South (Pearce, M.L.), Iceland (Benedikz, T.), Latvia (Pirags, D.), Netherlands (Kriek, W.), Northern Ireland (Savill, P.S.), and Norway (Magnesen, S.) Pollard, D.F.W., Teich, A.H., Logan, K.T. Seedling shoot and bud development in provenances of Sitka spruce. Weisgerber, H. Terminology and definitions to be used in certification schemes for forest reproductive materials.

57. DIK, E.J., JAGER, K. Choice of tree species in afforestation of dry, former arable land.
Nederlands Bosbouw Tijdschrift, 1977, 49(3): 131-137
9 ref.
Language: nl
Summary Languages: en
Subject Codes: 7.1, 7.4.4
CAB: 1032543

A detailed evaluation of the increment, yield and stability (ht/diam. ratio) of 7 species or provenances of pine (Pinus spp.) planted on dry loamy sands in Limburg district, Netherlands, at 14 and 18 years old. Results show that the Koekelare provenance of P. nigra var. maritima, followed by the Corsican provenance, are by far the best choices; the next best is P. nigra var. austriaca. P. sylvestris grew well but is not recommended owing to its susceptibility to Fomes annosus (Heterobasidion annosum) root rot; it was the least stable species. P. contorta and P. ponderosa did least well.

58. FORREST, G.I. Identification of unknown lodgepole pine origins.
Res. Info. Note, Forestry Commission, UK, 1977: No. 30, 4 pp.
Subject Codes: N/A
CAB: 1011912

Monoterpene patterns in the cortical resin of 4-year old trees of Pinus contorta indicated 15 major regions of origin in North America. Data for trees from 150 sources, growing in the UK or Ireland, were analyzed. Evidence was found for introgression from P. banksiana in four regions.

59. FORREST, G.I. Geographical variation in oleoresin monoterpene composition of Pinus contorta from natural stands and planted seed collections.
Biochem. Syst. Ecol., 1981, 9(2-3): 97-103
Subject Codes: 5.4
LISC: 649988

Monoterpene analysis was carried out on the shoot cortical oleoresin of natural stands of lodgepole pine sampled across an extensive part of its range in North America. The geographical variation in monoterpene composition was similar to that which had been previously deduced from analysis of planted origins grown in Britain from seed collected in North America. The independence of the monoterpene composition on the planting site was further shown by analysis of a number of trees grown in Sweden. Origins from the northern parts of the natural range showed that the biochemical region based on the Rocky Mountains extended northwards to northeast British Columbia and into the Yukon. Monoterpene data showed populations from this region to be characterized by unusually high variation in the biochemical genotypes encountered, and locally to show evidence of a close genetic relationship with Jack pine.

60. GARDINER, A.S., et al. Within-species variation and its genetical control.
Cambridge, UK; Institute of Terrestrial Ecology, 1981: 89-100
Subject Codes: 5.4
CAB: 1455440

Gardiner, A.S. Betula pubescens - the affinities of types in the Scottish highlands with those of continental Europe: a study of leaf morphology or the application of morphometrics. Cannell, M.G.R., Cahalan, C. Analysis of the variation within Sitka spruce, lodgepole pine and loblolly pine. Wilson, J. Within-species variants of trees for planting derelict land, with particular reference to Betula and Alnus spp.

61. GILBERTSON, R.L. A new vararia from western North America.
Madrono West, Amer. J. Bot., 20(5), 1970: 282-287
Subject Codes: N/A
BIO: 52018243

62. HAGNER, M. Geographic variation in Pinus contorta and picea mariana with respect to cone size, seedling growth rhythm and cotyledons. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note. No. 30, 1981: 83-101
15 ref.
Subject Codes: N/A
RCA: X1081

The material studied consisted of two-year-old seedlings of Picea mariana (9 provenances) and Pinus contorta (36 provenances) originating from the eastern foothills of the Rocky Mountains. A clinal change was found for cone size: number of cotyledons, time of budsetting, and for formation of secondary needles. Among seedlings of the two species originating from the same stand, the rate of shoot extension was faster for spruce.

63. HAGNER, M. Geographical variation in seed quality of lodgepole pine (Pinus contorta Dougl.) between and within stands. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 275-286
14 ref.
Subject Codes:
RCA: X1092

Results using regression analysis and X-ray analysis are provided.

64. HAGNER, S. Aspects on the introduction of foreign species in northern Swedish forestry.
Sver Skogsvardsforb. Tidskr., 67(8), 1969: 705-726
Subject Codes: N/A
BIO: 53031390

65. HAGNER, S., FAHLROTH, S. Some provenance experiments with Pinus contorta in north Sweden. IN: Pinus contorta Provenance Studies.

Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 64-70
Subject Codes: N/A
CAB: 1118600

66. ILLINGWORTH, K. Lodgepole pine provenance research and breeding in British Columbia. IN: Management of Lodgepole Pine Ecosystems USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 47-67
14 ref.
Subject Codes: 1.3, 2.7
CAB: 757499

Variation in the numbers of stomata on needles of wild and cultivated population samples was shown to be genetically determined and associated with provenance in Pinus contorta. Similar variation was observed in the juvenile growth behaviour of provenances in nurseries and field tests. The presence of substantial genetic variation within and between the principal regional forms of the species is inferred. The potential for its genetic improvement is briefly discussed. From author's summary.

67. ILLINGWORTH, K. Inter- and intra-provenance variation in heights of three-year-old Pinus contorta Dougl.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 98-106
3 ref.
Subject Codes: 5.1, 5.2
CAB: 1118606

68. ILLINGWORTH, K. Natural variation within lodgepole pine in British Columbia. IN: Pinus contorta provenance studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 40-42
2 ref.
Subject Codes: 5.4
CAB: 1118597

69. KANAK, K. Information for introduction of pinus-contorta in forest stands of Czechoslovakia.
Lesnictvi (Prague), 28(5), 1982: 379-398
Language: cs
Subject Codes: N/A
BIO: 75056714

In Czechoslovakia, there are only 2 localities with the series of provenances besides few cultures from previous times. The 1st series is located in the gene archives of the arboretum Sofronka near Plzen. It comprises 10 provenances 21 years old obtained from the US Department of Agriculture and 19 years old obtained from M. Holst (Petawawa Forest Experiment Station). An additional provenance from the IUFRO 1966 series, 14 years old in the forest district Krtiny are on the provenance area studied by Kantor. As the extent of the studied material is small, results from similar conditions in Germany were also used. Under the environmental conditions of both areas, the fastest growing provenances formed centralized areas (centers) similar to those of Scotch pine. The most important center is the coast of the states Washington and Oregon (USA), the 2nd concentrically around Lake Shuswap B.C. (British Columbia, Canada) and the center farthest to the North, but important for Czechoslovak conditions, is the territory along the Nass River, B.C. The study of 20 and 14 year gene archives of the arboretum Sofronka near Plzen makes a supplement; it comprises the evaluation of tree heights, diameters, stem shape, percent of fertile trees in the population and number of stemlets per tree.

70. KANTOR, J. The provenance study plot with pinus-contorta in Czechoslovakia.
Acta. Univ. Agric. Fac. Silvic., 49(1), 1980: 33-54
Subject Codes: 7.4.3
BIO: 71080494

Eleven provenances of P. contorta Dougl. in Czechoslovakia were studied. An assessment of individual progenies, 6 and 8 yr after planting, pointed invariably to very distinct differences between provenances. Under local conditions the southern coastal provenances of P. c. ssp. contorta appear to be most

promising, whereas the northern coastal P. c. ssp. contorta and the northern inland provenances of P. c. ssp. latifolia may be suitable to some extent. The intergrade type of p. c. ssp. latifolia-murrayana from the higher-lying mountain situations seems to be unsuitable also.

71. KARLMAN, M. The introduction of exotic tree species with special reference to Pinus contorta in northern Sweden. Review and background.
Studia Forestalia Suecica, 1981, No. 158: 25 pp.
73 ref., 8 pl.
Language: en
Summary Languages: sv
Subject Codes: 1.5, 6.2
CAB: 1442531

The large-scale planting of P. contorta in northern Sweden is reviewed in relation to: the distribution and characteristics of P. contorta within its natural range in W. North America; restrictions placed on planting by the Swedish Forestry Act of 1979; and parasitic fungi that infect P. contorta in W. Canada and their potential threat to indigenous P. sylvestris in Sweden.

72. KIELLANDER, C.L. Provenance trials with Pinus contorta.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1976, No. 18: 73-79
8 ref.
Language: sv
Subject Codes: N/A
CAB: 762932

Trials in progress are described. Preliminary results from regression analysis have shown that the most important independent variables tested are shift of latitude of the provenance material, shift of altitude squared, distance from the coast squared and latitude X distance from the coast.

73. KRIEK, W. Pinus contorta provenance trials in the Netherlands.
Nederlands Bosbouw Tijdschrift, 1973, 45(4): 141-153
1 ref.
Language: nl
Summary Languages: en
Subject Codes: N/A
CAB: 149028

Gives results of height measurements in 1972 in trial plots planted in 1967 and 1968 with a number of coastal and continental provenances of P. contorta from Ireland, and some from the USA, Canada and the Netherlands. Differences in height were considerable, and justify the preliminary selection of 15 Irish provenances suitable for use in the Netherlands. Stem form, and damage by Rhyacionia buoliana, were also assessed, but the differences observed between provenances do not affect the preliminary selection of provenances suitable for the Netherlands.

74. KRUTZSCH, P. The IUFRO series with Pinus contorta in Sweden. IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 71-73
Subject Codes: N/A
CAB: 1118601

75. LINDGREN, D. Pinus contorta provenances for Sweden.
Sveriges Skogsvardsforbunds Tidskrift, 1980, 78(1/2): 41-48
17 ref.
Language: sv
Summary Languages: en
Subject Codes: N/A
CAB: 1407088

76. LINDGREN, D., KRUTZSCH, P. et al. Survival and early growth of Pinus contorta provenances in northern Sweden.

Rapporter och Uppsatser, Institutionen for Sogsgenetik, 1976, No. 20: 42 pp. 21 ref.
Language: en
Summary Languages: sv
Subject Codes: N/A
CAB: 1107151

Survival and height were measured 4 years after planting out 83 provenances at 13 sites. In general, mortality was greater and height increment was less in southern provenances.

77. LINDGREN, D., LINDGREN, K. Survival and height increment of Pinus contorta IUFRO 70/71 series in Sweden. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meetng on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note. No. 30, 1981: 104-133
9 ref.
Subject Codes: N/A
RCA: X1082

Suggested provenance zones for Pinus contorta based on Rowe's 1972 Forest Regions of Canada are suggested and results of field trials of Canadian and U.S. origin seed are provided.

78. LINES, R. Pinus contorta provenance experiments in Britain. IN: Pinus contorta Provenance Studies.
Res. and Dev. Paper, Forestry Commission, UK, 1976, No. 114: 107-109
4 ref.
Subject Codes: N/A
CAB: 1118607

79. LINES, R. (Editor) Pinus contorta provenance studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 128 pp.
many ref., 8 pl.
Subject Codes: N/A
CAB: 1118594

The report of an IUFRO Working Party S2.02.06 meeting, held in Scotland in September, 1974, containing 13 papers.

80. LINES, R. (Chairman) Field experiments and performance of species: lodgepole pine provenances. IN: Proceedings of the IUFRO Working Party Mtg. - Vancouver, 1978.
Victoria, B.C., Canada, Ministry of Forests, Info. Services Branch, 1980, (2): 1- 158
many ref.
Subject Codes: N/A
CAB: 1358130

Reports on trials in Finland; Sweden; Norway; W. Germany; Britain; Ireland; and British Columbia.

81. LOCKE, F.M.L. The growing stock of regions.
Forestry (OXF), 51(1), 1978: 5-8
Subject Codes: N/A
BIO: 15038337

82. MACPHERSON, A.F. Lodgepole provenance.
Scottish Forestry, 23(1), 1969: 72-73
Subject Codes: N/A
BIO: 70089468

83. MASHCHINING, E. The variation of the number of cotyledons in some Pinus-contorta provenances.

Silvae Genet., 20(1-2), 1971: 10-14
Subject Codes: 2.7
BIO: 54007815

84. MOSS, E.H. Forest communities in Northwestern Alberta.
Can. Jour. Bot., 1953, No. 31:212-252
Subject Codes: N/A
RCA: X1215

85. NEWMAN, K.W., JANCEY, R.C. Sample size in studies of geographic variation.
Can. J. Bot., 59(11), 1981: 2158-2159
Subject Codes: 2.8, 4.0
BIO: 73081876

A procedure is described which provides an objective basis for selecting the number of individuals to sample at each location in studies of geographic variation within species. An example is given using cone data for Pinus contorta.

86. O'DRISCOLL, J. Pinus contorta international provenance experiments with IUFRO Working Party S2.02.06. IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 81-87
Subject Codes: N/A
CAB: 1118604

87. PERRY, D.A. Ecotypic variation in Pinus contorta Dougl. var. latifolia Engelm. (Lodgepole Pine).
Dissertation Abstracts International, B, 1975, 35(9): 4427
Subject Codes: 2.1
CAB: 471604

Seeds were collected from 10 trees in each of five stands located in Utah, Montana, Idaho, Washington, and British Columbia, and were grown under four different daylength regimes and two temperature regimes; other seedlings were grown under three different conditions of moisture stress. Data on the height, weight, and dates of bud-set and bud- burst were recorded for each seedling. Statistical analysis showed that there was a significant variation in height, the tallest seedling coming from parent stands with the longest growing season. There were no significant differences in the reaction of seedlings to daylength that could be correlated with the latitudinal position of the parent stands; however, seedlings from sources at high altitudes appeared to grow best at cool temperatures and with short days. Seedlings from parent trees in areas of summer drought resisted moisture stress somewhat better than other seedlings.

88. PERSSON, A., LINES, R. (Chairman). Pinus contorta as an exotic species. IN: Proceedings of the IUFRO Working Party Meeting in 1980 on Pinus contorta Provenances (S2.02.06) in Norway and Sweden.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1980, No. 30: 353 pp. many ref.
Subject Codes: 5.4, 6.0
CAB: 1358133

Some 24 papers are presented from the 8 sessions. Session I: Pinus contorta in its native environments. Nyland, E. Lodgepole pine in the Yukon. Session III: Volume increment. Hagglund, B. Growth and yield in planted lodgepole pine stands in Finland and Sweden. Session IV: Quality, including wood density. Brazier, J.D. A report on the effects of provenance on the timber properties of lodgepole pine, in the UK. Session V: Stability against wind and snow. Lines, R. Stability of Pinus contorta in relation to wind and snow. In the UK. Session VIII: Breeding beyond the provenance level. Skroeppa, T., Dietrichson, J., Skaret, G. Early testing of Pinus contorta in Norway. Discussion of alternative breeding strategies.

89. POLLARD, D.F.W. Certification and source data for Pinus contorta seed exported from Canada. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances

(S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 313-327
23 ref.
Subject Codes:
RCA: X1095

Procedures and statistics are presented for certification of source-identified lodgepole pine seed collected in Canada. Existing Swedish transfer rules favour inventory of potential resources through successive approximation, especially from satellite imagery, but a flexible data bank is required. Systems developed or acquired by the Canadian Forestry Service are described, including Yukon RRAMS (renewable resource and management statistics) and EXIR (executive information retrieval). Progress in adopting EXIR for forest genetic resource information is described.

90. REMROD, J. The lodgepole pine.
Kungl; Skogs-och Lantbruksakademiens Tidskrift, 1977, 116(3): 149-179
Language: sv
Summary Languages: en
Subject Codes: N/A
CAB: 801922

Results from two five-year-old experimental plots of Pinus contorta var. latifolia at latitudes of 63 deg 46' and 65 deg 55'N show that the material of north Canadian provenance survived the best. A preliminary seed transfer scheme for the selection of provenance material in north Sweden is presented.

91. ROBERTS, J., WAREING, P.F. A study of the growth of four provenances of Pinus contorta Dougl.
Annals of Botany, 1975, 39(159): 93-99
10 ref.
Subject Codes: 5.1
CAB: 514266

A study made of the growth of third-and-fourth year seedlings of four provenances of P. contorta, two of which were from high elevations and two from coastal sites. Marked differences in height growth were observed, the two coastal provenances showing significantly greater growth than the two montane ones. These growth differences were due to differences in the numbers of needle and stem 'internode' primordia laid down in the resting buds in the preceding year, and not to differences in 'internode' length in the annual extension shoots. The differences in height growth were paralleled by differences in dry weight. A greater relative height growth rate was shown by one coastal provenance, and probably also by the second, than by the montane provenances. The amounts of reserve materials were similar in all provenances. These results are discussed, and it is concluded that the growth on montane provenances may be 'sink- limited' rather than 'source-limited' when they are grown at lower altitudes.

92. ROSVALL, O. A new series of Pinus contorta provenance trials in northern Sweden.
IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 143-154
5 ref.
Subject Codes: N/A
RCA: X1083

Results from an experimental series five years after planting including twenty provenances of Pinus contorta and three or four provenances of Pinus sylvestris on seven localities in northern Sweden, show very high survival for most of the provenances originating from northern British Columbia and Yukon and for all Pinus sylvestris provenances.

93. SAVILL, P.S. Lodgepole pine provenance trials in Northern Ireland. IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 88-97
7 ref.
Subject Codes: N/A
CAB: 1118605

94. SCHAEFER, D.G., KRAJINA, V.J., HADDOCK, P.G. et al. Proceedings of the IUFRO joint meeting of working parties, Vancouver, Canada, 1978, 2 vols.
Victoria, B.C., Canada, Ministry of Forests, Info. Services Branch, 1980: vii + 426 pp.
many refs.
Subject Codes: 4.1, 6.4
CAB: 1358127

Papers presented at a meeting held from August 21 to September 9 of S2.02.05 (Douglas-fir provenances), S2.02.06 (lodgepole pine provenances), S.02.12 (Sitka spruce provenances), and S2.02.14 (Abies provenances). Most papers relate to the species. There are six general papers: Schaefer, D.G. An overview of the climates of western North America. Krajina, V.J. Vegetation of western North America. Haddock, P.G. Environmental characteristics of western North America with special reference to forestry (abstract only). Fletcher, A.M., Barner, H. The procurement of seed for provenance research with particular reference to collections in NW America. Pollard, D.F.W. Canadian participation in the OECD scheme for control of forest reproductive material moving in the international trade. Barner, H. Implementation of results from provenance research.

95. SEAL, D.T., FORREST, G.I., PHILIPSON, J.J., PARKES, H. Geographical variation in the monoterpenes of the resin of Pinus contorta.
Luxembourg; Commission of the European Communities, 1977: 55-71
Language: en
Summary Languages: fr, de
Subject Codes: 1.2, 5.4
CAB: 1358277

96. SHELBOURNE, C.J.A. Report of forest research 1975.
UK, Forestry Commission, London, UK, 1975: 104 pp.
Subject Codes: 5.4
CAB: 750162

During a four-month advisory visit C.J.A. Shelbourne devised a new breeding strategy for Pinus contorta. The Genetics Branch of the Research and Development Division is now responsible for ensuring that all seed for use in commercial forestry is from stands which comply with European Community standards, that seed orchards are established for Pinus and Picea sitchensis and that existing untested Pinus sylvestris orchards be replaced by test orchards. Interim reports on provenance trials in progress are presented for Picea sitchensis, Pinus contorta, Abies grandis, Alnus rubra, Pinus nigra and hybrid larch.

97. SKROEPPA, T., DIETRICHSON, J. Survival and early growth of Pinus contorta provenances in interior eastern Norway.
Meddelser fra Norsk Institutt for Skogforskning, 1978, 34(3): 69-92
17 ref.
Language: en
Summary Languages: no
Subject Codes: 7.4.3
CAB: 1216143

In spring 1969 2+1 transplants were planted at 6 sites, each with 20 provenances, 9 of which were included in all the trials. A total of 37 provenances from British Columbia, Alberta, and 6 northern states of the USA was used, selected from 71 provenances previously used in a nursery study. Measurements of survival and ht. were made every other year until 1976. Both characters varied between the sites and the 9 common provenances. Cumulative mortality in 1976 was 20-40% at 5 of the sites (mainly in the first 2 yr.) but was 86% at the most frost-prone site. Mortality was lower and ht. growth greater for the northern (lat. 54 deg to 56 deg N.) than for the southern provenances. There was only a very weak correlation between the nursery and field values for mortality and ht. growth.

98. SKROEPPA, T., KOENH, F., et al. A conference on Pinus contorta.
As, Norway; Norsk Institutt for Skogsforskning, 1977, 58 pp.
Language: no
Subject Codes: 6.2, 7.2, 8.1
CAB: 984174

Includes the following papers read at a Norwegian conference in the autumn of

1976: Skroeppa, T. (Results of provenance trials with P. contorta in Norway). Koehn, F. (P. contorta planted in spring 1973.) Magnesen, S. (P. contorta in the Vestland.) Wilhelmsen, G.; Gislerud, O. (Properties and utilization of P. contorta wood.) Roll- Hansen, F. (Fungus damage on P. contorta.) Magnesen, S. (Supply of P. contorta seed.)

99. STEPHAN, B.R. Intraspecific variation of Pinus contorta in field trials in Federal Republic of Germany. I. Early results of series of 1960-61.
Silvae Genet., 1976, 25(5-6): 201-209
Language: de
Summary Languages: en
Subject Codes: 5.4, 7.4.3
LISC: 019926

A total of 11 provenances of Pinus contorta from the natural range of this species have been grown in field trials at 6 test locations in the Federal Republic of Germany. The provenances belong to the following 3 of 4 P. contorta subspecies: ssp. contorta (coastal form), ssp. latifolia (inland form), ssp. murrayana (inland form). The seed lots were sown in 1958, the 6 field trials were established in 1960/1961. Measurements and observations were recorded for the traits: height growth, stem diameter, mortality, and damages by pine shoot moth attack (Rhyacionia buoliana). With regard to height growth and stem diameter, significant differences between provenances were found. Coastal provenances (ssp. contorta) as well as few inland provenances (ssp. latifolia) from the middle of the natural range of this subspecies showed at the age of 15 years a performance above the overall growth rate. The performance of inland provenances of ssp. murrayana was unsatisfying. Height growth of all provenances was influenced very strongly by the test location. The mortality was limited and relatively high only a few locations. Total loss of provenance could not be observed, although there were provenance-dependent differences in mortality at the single locations. A high percentage of trees showed at the age of 18 years damages caused by repeated pine shoot moth attack. Differences both between sites and provenances could be proved. Coastal provenances (ssp. contorta) seemed to be damaged more severely than inland provenances of the subspecies latifolia and murrayana.

100. STEPHAN, B.R. Intraspecific variation of Pinus contorta on trial grounds in the German Federal Republic. II. Results of the 1971/1982 IUFRO trial series.
Silvae Genetica, 1980, 29(2): 62-74
18 ref.
Language: de
Summary Languages: en
Subject Codes: 6.4, 7.4.3
CAB: 1360898

Two-year old trees representing P. contorta subspp. contorta, latifolia, bolanderi and murrayana, collected from 140 provenances in western North America, were planted in a total of eight trials at six sites in the German Federal Republic. The best growth during the first six years of the trials was made by coastal provenances of subsp. contorta from Oregon, Washington and British Columbia. Inland provenances of subsp. latifolia from British Columbia also made good growth. At the end of the trials, the reproductive phase had begun in trees from the northern coastal and inland provenances, but not in the more vigorous coastal provenances. Mortality, chiefly due to drought, tended to be greater in the more vigorous provenances. Susceptibility to frost was greatest in the three provenances of subsp. bolanderi from California, and was generally greater in coastal than in inland material. Damage caused by Rhyacionia buoliana was less severe in subsp. murrayana than in subsp. contorta.

101. WHEELER, N.C., GURIES, R.P. Population structure, genetic diversity and morphological variation in Pinus contorta.
Can. J. For. Res., 12(3), 1982: 595-606
Subject Codes: 1.2, 3.0, 5.4
BIO: 75031719

Lodgepole pine (P. contorta Dougl.) occupies a large and ecologically diverse range in western North America. The species is generally recognized as consisting of 4 ssp., 3 of which are widespread (P. c. ssp. bolanderi) endemic to the north coast of California (USA). Geographic isolation of subspecies is nearly complete although gene flow may occur in certain instances. Moderate heterozygosity estimates (0.10-0.14) and low SE of the estimate (0.02-0.04) were obtained for all populations and are comparable with other recent studies of

conifers that based estimates on greater than or equal to 20 loci. The distribution of allozyme variation indicates that very little population differentiation has occurred. Of the allozyme variability, approx. 91% resides within populations, with 3 and 6% distributed among subspecies and among populations, respectively. The extent of population differentation is far less than that observed for many herbaceous plants, but similar to reports for other conifers. In contrast, a large proportion of morphometric variation in lodgepole pine cone and seed traits is distributed among subspecies (38%) and among populations within subspecies (19%). This may be attributed to the effects of strong selective pressures acting on important reproductive structures and to the conventional methodology for analyzing morphometric variation. With minor exceptions, an earlier taxonomic treatment of lodgepole pine in the Cascade Range of southern Oregon (USA) to P. c. ssp. murrayana is probably inappropriate. While morphological data suggest a close affinity to P. c. ssp. murrayana, allozyme data suggest that populations in this area should be assigned to P. c. ssp. latifolia.

102. YING, C.C. Variation in lodgepole pine with special reference to British Columbia. E.P. 657. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C. 1983: 62-65
Subject Codes: 1.5
RCA: X1068

This study has found that, in terms of height growth, lodgepole pine may be divided into two broad geographic groups which are detailed on a map showing the location of 153 Pinus contorta provenances. Studies have been carried out on site, provenance x site interaction, cone production, genetic variation and provenance.

## 1.5 RANGE AND OCCURRENCE

103. CHAPMAN, R.C., LE MASTER, D.C., WEATHERHEAD, D.J. Forestry in the inland empire.
Journal of Forestry, 1980, 78(9): 534-536, 552
2 pl. (1 col.)
Subject Codes: N/A
CAB: 1315667

A discussion of forestry in eastern Washington, the panhandle of Idaho, and NE Oregon. Topics covered include: vol. of growing stock (29% Douglas-fir, 19% true firs, 14% ponderosa pine, 11% lodgepole pine, 7% western larch, Larix occidentalis); annual growth, mortality and harvesting; wildfire, diseases and insects; timber management and logging methods; and nontimber uses.

104. HOFFMANN, G.R., ALEXANDER, R.R. Forest vegetation of the Bighorn Mountains, Wyoming: a habitat type classification.
USDA For. Serv. Res. Paper, Rocky Mountain For. and Range Exp. Stn., 1976, No. RM-170: 38 pp.
26 ref., 15 pl.
Subject Codes: 3.6
CAB: 868456

A vegetation classification based on concepts and methods developed by Daubenmire was used to identify 14 habitat types and related phases in these mountains. These types include five in the Pinus ponderosa series, three in the Abies lasiocarpa series, two each in the Pseudotsuga menziesii and Pinus contorta series, and one each in the Populus tremuloides and Picea engelmannii series. A key for identification of the habitat types is provided, and notes are included on the implications of each type for forest management.

105. KENNEDY, R.W. 1985. Lodgepole pine as a commercial resource in Canada. Pages 21-23 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Volumetrically, lodgepole pine ranks second among species harvested in B.C. and Alberta, exceeded only by the spruces. Although it comprises only 15 percent of the mature standing timber in B.C. and 20 percent in Alberta, it accounts for 20 and 40 percent of the annual harvest in these respective provinces. Stumpage value of lodgepole pine in B.C. is the lowest of the ten species commonly harvested, owing mainly to its small piece size. The value of

shipments of forest products made from lodgepole pine is estimated at $2.4 billion for 1982. In the lumber form it is sold in the Spruce-Pine-Fir group (SPF), while its veneer appears in plywood as Canadian Softwood Plywood (CSP). It supplies pulpwood largely as chips in B.C., while in Alberta, the major form of pulpwood is in the roundwood form. Poles, ties, mechanically stress-rated lumber, and remanufactured items round out the list of other products produced from lodgepole pine.

106. MACDONALD, G.M., CWYNAR, C. 1985. A fossil pollen based reconstruction of the late quaternary history of lodgepole pine (Pinus contorta ssp. latifolia) in the western interior of Canada. Canadian Journal Forest Research. 15(6):1039-1044.

Previous reconstructions of the late quaternary biogeographical history of lodgepole pine have been based upon inferences from the modern geographical distribution of morphological and genetic variation. These studies have led to the widely accepted conclusion that relict populations of the Rocky Mountain subspecies of lodgepole pine (ssp. latifolia) persisted in glacial refugia located in NW Canada. New fossil pollen evidence of the late Pleistocene and Holocene distribution of lodgepole pine in the interior of Canada contradicts this view. P. contorta ssp. latifolia migrated north into Canada from refugia located south of the continental glacial limits and did not reach its northern range limits in the southern Yukon until the late Holocene.

107. SCOTTER, G.W. Distribution of pine, pinus-spp in the south Nahanni and Flat Rivers region, Northwest Territories.
Can. J. For. Res., 4(4), 1974: 555-557
Subject Codes: 3.1
BIO: 59047406

108. SLATER, J.R. Pinacae distribution in the State of Washington, USA.
Occasional Paper, Museum of Natural History, University of Puget Sound (51), 1978: 694-709
Subject Codes: N/A
BIO: 67039425

In the class Pinacae there are about 500 spp., widely distributed, mostly in temperate to subartic areas. Of the 7 families, 3 are found in Washington (USA): yew (with 1 sp.), cypress (with 5 spp.) and pine (with 15 spp.) totaling 21 (Taxus brevifolia, Chamaecyparis nootkatensis, Juniperus communis, J. occidentalis, J. scopulorum, Thuja plicata, Abies amabilis, A. grandis, A. lasiocarpa, A. procera, Larix lyallii, L. occidentalis, Picea engelmannii, P. sitchensis, Pinus albicaulis, P. contorta, P. monticola, P. ponderosa, Pseudotsuga menziesii, Tsuga heterophylla and T. mertensiana). The distribution maps presented indicate only one location in each county for a species that generally indicates the 1st specimen location found. There are very likely many other locations where the species grows in that county. Ecological implications are also discussed

109. VAN HOOSER, D.D., KEEGAN, C.E. III. 1985. Lodgepole pine as a commercial resource in the United States. Pages 15-19 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University. Pullman, WA.

Lodgepole pine (Pinus contorta Dougl. ex Loud.) has contributed greatly to the early economic development of the northern and central Rocky Mountain regions. In the last decade annual lumber production from lodgepole pine has averaged between 2.5 and 3.5 Mm3 (500 and 700 million board feet). Lodgepole currently accounts for 1 percent of the nation's total lumber output. In the Rocky Mountain States it accounts for 16 percent of the annual lumber harvest; on a state-by-state basis it accounts for between 20 to 70 percent. Currently, there are approximately 8,000 jobs associated directly, or indirectly, with lodgepole pine processing in the region.

110. WHEELER, N.C., CRITCHFIELD, W.B. 1985. The distribution and botanical characteristics of lodgepole pine: biogeographical and management implications. Pages 1-13 in Lodgepole pine : the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Lodgepole pine (Pinus contorta Doug.) is the most widely distributed conifer in western North America. Its range, centered in British Columbia, spans 33 deg of longtitude and over 3900 m of elevation. The species' edaphic and climatic tolerances are remarkable. In view of the ecological variability encountered by lodgepole pine, it is little wonder that the species exhibits considerable genetic variation. Three well-differentiated, interfertile geographic races have evolved in the coastal, Rocky Mountain-Intermountain, and southern Cascade-Sierra Nevada regions. A fourth, endemic race of lesser significance has evolved in the Mendocino White Plains of the northern California coast. These races differ in tree longevity, dimensions, form and branchiness; needle, seed and cone characteristics; and biochemical traits. This paper draws from a vast literature to document the variability in botanical characteristics observed in lodgepole pine. Emphasis is on subspecies latifolia. Observed patterns of variation are discussed in conjunction with day-to-day management decisions and current views on the biogeography of lodgepole pine.

111. WHEELER, N.C., GURIES, R.P. 1982. Bio-geography of lodgepole pine Pinus contorta. Canadian Journal of Botany. 60(9):1805-1814.

Lodgepole pine has been a component of the western north America flora throughout recent geological history, although its present widespread distribution may be a relatively recent phenomenon (late Pleistocene). The differentiation of populations within and between subspecies and the distribution of rare alleles both suggest that at the time of maximal Wisconsin glacial advance lodgepole pine was restricted to a number of refugia in the western USA, the islands along the north Pacific coast and in an unglaciated region of the west-central Yukon (Canada). Subsequent to glacial retreat, lodgepole pine migrated to its present range with northern and southern interior populations meeting in northern British Columbia (Canada), possibly within the last 4000 yr.

## 2.0 SPECIES CHARACTERISTICS

### 2.1 PHENOLOGY

112. CANNELL, M.G.R., WILLETT, S.C. Rates and times at which needles are initiated in buds on differing provenances of Pinus contorta and Picea sitchensis in Scotland.
Canadian Journal of Forest Research, 1975, 5(3): 367-380
26 ref.
Subject Codes: 1.4
CAB: 665748

Bud formation was monitored on trees from four sources and on one intersource hybrid of P. contorta, at age ten years, also on trees from five sources of Picea sitchensis at age eight years, all grown in trials in Scotland. Trees representing sources throughout the natural ranges of the species were included in the trials. In both species extension growth occurred between late May and mid-July. In P. contorta, buds began to form in April, about one-third of the following year's needles (auxiliary bud primordia) being formed before mid-July, and all by mid-September. In Picea sitchensis, bud formation occurred from May to October. Trees from northerly and inland montane sources began to produce primordia earlier than those from southerly sources; this suggests that trees from different sources differ in temperature sensitivity. The dates when bud development ceased were more closely related to latitude of seed origin, which suggests differences in sensitivity to photoperiod. Differences between trees from different numbers of primordia formed were related in the pine to differences in maximum rates of initiation during the summer, and in the spruce to differences in seasonal duration of growth. In all cases, rates of initiation were closely correlated with diameter of the apical dome. Implications for conifer breeding and genotype environment X interactions are noted.

113. CANNELL, M.G.R., WILLETT, S.C. Shoot growth phenology, dry matter distribution and root:shoot ratios of provenances of Populus trichocarpa, Picea sitchensis and Pinus contorta growing in Scotland.
Silvae Genetica, 1976, 25(2): 49-59
34 ref.
Language: en
Summary Languages: de
Subject Codes: 1.2, 2.3, 2.5
CAB: 812659

Material of Populus trichocarpa from 62 localities, of Picea sitchensis from 54 localities and of Pinus contorta, from seven localities, the sites ranging from California to Alaska, was grown at one Scottish site and analyzed at 1-3 week intervals over 1-3 years. In all three species, differences in the root: shoot dry-weight ratios at the end of the season reflected the extent to which shoot growth was adapted to the climate in which they were grown rather than inherent differences in the functional balance between roots and shoots. Provenance material which stopped increasing in height early in the growing season tended to have higher root:shoot dry-weight ratios as the period of root growth after shoot growth ceased was longer. Provenance material of Picea sitchensis and Pinus contorta that had large preformed shoots developed less root than those with small preformed shoots, even though the periods of shoot elongation were of the same length.

114. CARLSON, L.W. Root initiation of lodgepole pine and white spruce seedlings grown under varying light conditions.
Bi-monthly Research Notes, 1976, 32(4): 21-22
4 ref.
Subject Codes: 2.3
CAB: 699164

Dormant seedlings of (a) Pinus contorta var. latifolia (2+0) and (b) Picea glauca (3+0) were potted in sand. One set of seedlings was kept in the dark for 0-30 days, after which they were exposed to continuous light for 0-30 days. Another

set was maintained for 30 days in full light, half light or complete darkness. It was found that root initiation in (a) was stimulated by light and suppressed by dark periods whereas in (b) initiation was not dependent on light, but the number of new roots per plant was related to light intensity. Initiation did not vary greatly between full and half light; this suggests a hormonal rather than a photosynthetic response.

115. CUNNINGHAM, A., ROBERTS, Q.W. Shoot growth studies of Pinus contorta, Pinus mugo, and Larix decidua in the Kaweka range.
New Zealand Journal of Forestry, 1972, 17(1): 91-100
7 ref.
Subject Codes: 2.5
CAB: 068014

Gives data on monthly shoot length increment in young plantations on six different sites between 1034 and 1465 m alt. in New Zealand, in two growing seasons. Variability of growth between individual trees was greatest in P. contorta and least in L. decidua. P. contorta had a longer growing season than the other two species. Initiation of growth occurred later on the higher sites, and earlier on bare erosion surfaces.

116. DAUGHERTY, J.R. Remote sensing of selected biological phenomena in lodgepole pine.
Dissertation Abstracts International, B, 1976, 36(8): 3697
Subject Codes: 3.0, 8.4
CAB: 892456

Measurements were made of transpiration rate, moisture stress level, crown surface temp., crown air temp., RH, phenological date, ambient air temp. and duration of sunshine in a lodgepole pine (Pinus contorta) forest in Little South Fork Experimental Watershed, (Colorado). The data were used to develop sets of equations to predict transpiration rate and total water loss over a given period, using various combinations of the other measured parameters.

117. DYKSTRA, G.F. Photosynthesis and carbon dioxide transfer resistance of lodgepole pine seedlings in relation to irradiance, temperature and water potential.
Canadian Journal of Forest Research, 1974, 4(2): 201-206
26 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 304766

In a laboratory study on 2-year-old Pinus contorta seedlings, photosynthesis and stomatal and total equivalent mesophyll resistances to C02 transfer were measured in relation to irradiance, needle temperature, and tree water potential. Maximum rates of net photosynthesis were attained at 380 W/m2 irradiance, 20 deg C needle temperature, and the highest tree water potential obtained, viz. ca. -2.5 bars. Stomatal and total mesophyll resistances have a significant rate-limiting role when environmental conditions are below the optimum; the photosynthetic response obtained in the study is attributed to growing the trees under optimum conditions. Mesophyll resistance was greater than stomatal resistance under all the environmental conditions tested.

118. EKBERG, I., ERIKSSON, G., DORMLING, I. Photoperiodic reactions in conifer species.
Holarctic Ecol., 1979, 2(4): 255-263
Subject Codes: N/A
LISC: 467328

In Picea abies seedlings the critical night length for bud-set was determined for provenances from different latitudes, longitudes and altitudes within the natural range of the species. Inheritance studies indicated that this character is controlled by many genes with predominantly additive effects. In seedlings of Pinus sylvestris and Pinus contorta, growth cessation and bud-set took place in all light regimes, even under continuous illumination. A photoperiodic optimum for height growth was determined. The photoperiodic influence on such characters as recurrent flushing of shoots, needle growth, dry matter production and frost resistance was demonstrated for northern and southern populations of the 2 Pinus

species. Shorter nights were needed to induce a particular photoperiodic response in the northern populations as compared with those from the south. The importance of reliable phenological characters for assessing frost hardiness in provenance and progeny trials by means of early tests, is discussed.

119. ERIKSSON, G. Do flowering characteristics constitute a constraint for forest tree breeding in Sweden? IN: Third World Consultation on Forest Tree Breeding. Session 4. Constraints on Progress.
Canberra, Australia; CSIRO, 1978: 883-893
7 ref.
Subject Codes: 2.8, 5.4
CAB: 1095136

Frequency of flowering varies greatly between clones in Picea abies and Pinus sylvestris and between provenances in Pinus contorta.

120. HAGNER, M. A general ecological investigation of the annual rhythm of pinus contorta and a comparison with Pinus sylvestris.
Stud. Forest Suecia (81), 1970: 5-26
Subject Codes: N/A
BIO: 52019675

121. HAGNER, M., ASPERGREN, G. Colour analysis for assessment of the maturity of pine needles.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1977, No. 27: 109-116
7 ref.
Language: sv
Summary Languages: en
Subject Codes: 1.2
CAB: 1358349

122. JOHNSON, L.C., CRITCHFIELD, W.B. The production of functional pollen and ovules by pine seedlings less than 1 year old.
For. Sci., 24(4), 1978: 467-468
Subject Codes: 2.8, 4.0
BIO: 68047385

Seedlings of Pinus contorta and P. contorta X banksiana produced functional pollen and ovules respectively at less than 1 yr of age. None of their offspring flowered until the age of 2 yr or more.

123. MOIR, W.H. Seasonal variations of plant and stand dehydrature in contrasting forest habitats - Colorado Forest Range, 1970.
US IBP (Int. Biol. Program), Anal. Ecosyst., Program Interbiome. Abstr., 1(4), 1971: 257-258
Subject Codes: N/A
BIO: 72027251

124. NILSSON, J.E. Flowering in Pinus contorta. A study of flowering abundance and flowering phenology of provenances from latitude 48 deg. N to 63 deg. N in a Swedish field trial.
Institutionen for Skoglig Genetik och Vaxtfysiologi, Sveriges Lantbruksuniversitet, 1981, No. 2: 128 pp.
many ref.
Language: en
Summary Languages: sv
Subject Codes: 1.2, 1.4
CAB: 1539716

A paper presented as a thesis for a doctor's degree at the Swedish University of Agricultural Sciences, Umea. Flowering was observed on 14 to 17-year old trees of 14 Canadian provenances at Ange, central Sweden (lat. 62o 32' N, alt. 425-440 m) in 1976-80. In Ange, a northern latitude of the seed source favoured abundant female flowering and at least in the harsh climate of Volgsele, also male flowering. The number of strobili varied considerably more within a provenance

than between the provenances. Inter-provenance variation in the onset of pollen dispersal and female receptivity was small. Both male and female flowering were more abundant in P. contorta than in the native P. sylvestris; the flowering period was the same for both species, with the exception of the southernmost P. contorta provenances. Male flowering especially, but also female, begins at an earlier age in P. contorta; this is an advantage for breeding work and seed production.

125. NILSSON, J.E., ERIKSSON, G., RUDIN, D. Studies on flowering biology in 14 provenances of Pinus contorta in a Swedish field trial. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 299-311
3 ref.
Subject Codes: N/A
RCA: X1094

Flowering biology of 14 provenances of Pinus contorta var. latifolia from 48 deg. N to 63 deg. N has been studied for three years. The flowering time was found to be strongly correlated with the latitude of the seed source. Individual differences within provenances were found with respect to abundance and phenological characteristics. These are discussed.

126. OWSTON, P.W., SMITH, J.L., HALVERSON, H.G. Seasonal water movement in tree stems.
Forest Science, 1972, 18(4): 266-272
16 ref.
Subject Codes: 2.11
CAB: 141163

Reports work on Abies magnifica (a) and Pinus contorta (b) in California. Results support the assumption that P32 ascends with the transpiration stream. No transpiration stream could be detected in (b) during winter, indicating a possible physiological difference between (a) and (b). Transpirational movement in (a) during winter was no greater than that recorded for spruce in more extreme climates. Diurnal movement was studied in two dominant trees of (b), 20 m high, in clear weather in Oct. 1968: the maximum of ascent was 26 cm/hour; the volume movement of water ranged from 0.2 litre/hour per tree at night to 5.3 litre/hour per tree after midday; the total transpiration of the stand was estimated at 0.16 cm/day.

127. REHFELDT, G.E., WYKOFF, W.R. Periodicity in shoot elongation among populations of pinus-contorta from the northern Rocky Mountain area.
Ann. Bot. (Lond.), 48(3), 1981: 371-378
Subject Codes: 2.5, 5.4
BIO: 73030924

Periodicity in 3rd yr shoot elongation was assessed in 15 lodgepole pines from each of 30 populations. Periodic measurements of shoot elongation were made on seedlings growing in a greenhouse. Data were fitted to regression models that accounted for nearly all the variance in seasonal elongation of individual trees. Regression statistics allowed calculations of the initiation, rate, duration, cessation and amount of elongation of individual trees. Analyses of variance showed that populations differed little in the initiation of shoot elongation, but exhibited tremendous genetic divergence in the rate, duration, cessation and amount of elongation. Patterns of differentiation were strongly and negatively related to the elevation of the seed source.

128. SAVIDGE, R.A., WAREING, P.F. Apparent auxin production and transport during winter in the nongrowing pine Pinus-contorta tree.
Can. J. Bot., 60(5), 1982: 681-691
Subject Codes: N/A
BIO: 75055891

Endogenous IAA was characterized by combined gas chromatography-mass spectroscopy (GC-MS) in inactive cambia of P. contorta Dougl. and Larix decidua Mill. during winter, and IAA levels were estimated by GC-MS in buds, needles and the tissues comprising the inactive cambial region of P. contorta during late autumn and winter. Supplementary IAA estimates were obtained for cambia of Acer pseudoplatanus L., L. decidua, Populus .times. canadensis cv. Robusta and

Quercus robur L. IAA levels in cambial tissues were higher than those in similar-aged tissue of hardwoods throughout the winter. Winter disbudding and defoliating treatments reduced levels of endogenous IAA in the cambial region of lodgepole pine. Exogenous (14C) IAA and (14C) sucrose were transported downward in the stem during winter. Microscopy suggested functional sieve cells to be present during winter and the moisture content of the cambial region of lodgepole pine was more than twice that of overwintering hardwoods. The vascular cambium of P. contorta probably is not dependent upon a supply of IAA from extending shoots and growing needles for its reactivation in spring. Apparently, IAA production and export from metabolically active buds and mature needles may occur during winter.

129. SCHMIDT, W.C., LOTAN, J.E. Phenology of common forest flora of the northern Rockies - 1928 to 1937. USDA Forest Research Paper INT-259: 20 pp.
Subject Codes: N/A
RCA: X1202

130. SHAUKAT, S.S., MOORE, K.G., LOVELL, P.H. Some effects of triazines on growth, photosynthesis and translocation of photosynthate in Pinus-spp.
Physiol. Plant, 33(4), 1975: 295-299
Subject Codes: N/A
BIO: 60034020

## 2.2 FORM

131. BROWN, J.K. Weight and density of crowns of Rocky Mountain conifers.
USDA For. Serv. Res. Paper, Intermountain For. & Range Exp. Stn., 1978, No. INT-197: 56 pp.
31 ref.
Subject Codes: 5.1, 5.6
CAB: 1032666

Relations between live and dead crown weight and d.b.h. (from 0-40"), crown length, tree height and crown ratio are presented for 11 species, from reported measurements and field measurements in western Montana and northern Idaho. D.b.h. was highly correlated with crown weight; precision of estimates was improved for most of the difference in crown weight between dominant and intermediate crown classes. Relations between bole weight and d.b.h. and height are given for trees of up to 40" d.b.h. Accumulative fractions of foliage and branchwood and their relation to d.b.h. are presented. Bulk densities for foliage and branchwood of live crowns range from 0.04 to 0.14 lb/ft3 and are approximately twice those of foliage alone. Bulk densities and m.c.'s are greater in the upper crown.

132. CANNELL, M.G.R. Some causes and consequences of differences in height growth and branch frequency on differing provenances of Pinus contorta.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 43-51
2 ref.
Subject Codes: 1.4, 5.1, 5.4
CAB: 1118598

133. COLE, D.M. Canopy development in lodgepole pine: Implications for wildlife studies and multiple resource management.
INT For. & Range Exp. Stn., For. Serv. Gen. Tech. Rep. INT-139, 1983: 13 pp.
Subject Codes: 8.0, 8.8
RCA: X1114

The report describes the use of lodgepole pine crown development models with computerized stand projection programs for examining the effects of alternative timber management prescriptions on canopy characteristics important to wildlife. Instructions are given for exploiting existing data bases with the crown models; and for using the models and procedures to test and refine current forest wildlife

cover concepts.

134. FRANKLIN, E.C., CALLAHAM, R.Z. Multi-nodality branching and forking in lodgepole pine.
Silvae Genet., 19(5-6), 1970: 180-184
Subject Codes: 6.1, 6.4
BIO: 52095594

135. KIMES, D.S., SMITH, J.A., BERRY, J.K. Extension of the optical diffraction analysis technique for estimating forest canopy geometry.
Aust. J. Bot., 1979, 27(5): 575-588
Subject Codes: 8.4
BIO: 69057522

Optical diffraction analysis of in situ ground photographs has previously been used to estimate foliage angle distribution in grassland canopies. These canopies are typically characterized by a single component, leaves, and the foliage is highly linear in nature. In this paper, the diffraction technique is extended to a multicomponent forest canopy containing needles and branches. Additional convolution and coordinate transformations are used to estimate the branch and needle angle frequency distributions for top, middle and base sections of 2 lodgepole pine (Pinus contorta) trees. The resulting distributions show that the branch inclination angles tend to increase as one proceeds to the tree tops. The needle inclination angle distribution was relatively constant for all layers, and it is believed that this distribution is characteristic of a large class of needle-bearing species.

136. WARING, R.H., SCHROEDER, P.E., OREN, R. Application of the pipe model theory to predict canopy leaf area.
Can. J. For. Res., 12(3), 1982: 556-560
Subject Codes: 2.7, 5.6
BIO: 75032842

The pine model theory presents the idea that a unit weight of tree foliage is serviced by a specific cross-sectional area of conducting sapwood in the crown. Below the crown, a large fraction of the tree bole may be nonconducting tissue, so the sapwood area would have to be known to estimate foliage. The pipe model theory was applied to the analysis of several western coniferous species including Pinus contorta Laud. var. murrayana (Balf) Engel. and Pinus ponderosa Dougl., to learn whether the distribution of canopy leaf area could be accurately estimated from knowledge of the sapwood cross-sectional area at various heights, including breast height (1.37 m). Results are excellent, but taper in the conducting area must be considered when sapwood area is measured below the crown.

## 2.3 ROOT SYSTEMS

137. BOGGIE, R. Water table depth and oxygen content of deep peat in relation to root growth of Pinus-contorta.
Plant Soil, 48(2), 1977: 447-454
Subject Codes: 2.11, 3.6, 8.8.3
BIO: 67040153

02 concentrations were measured at monthly intervals in deep peat in plots in which the water-tables are maintained artificially at levels ranging in depth from 11-33 cm below the surface. Good correlation was observed between weight of roots of 11 yr old P. contorta in these plots and 02 concentrations in different horizons at all times of the year, although strongest correlations coincided with the winter months when 02 concentrations are lowest, indicating that the root pattern is determined more by adverse rather than optimum seasonal conditions.

138. BURDETT, A.N. Root form and mechanical stability in planted lodgepole pine in British Columbia.

Ministry of Forests & Canadian Forest Service, 1978: 162-165
8 ref., 2 pl.
Subject Codes: 7.3, 7.4
CAB: 1107345

A method is described in which planting stock is raised in containers coated with a paint containing basic cupric carbonate (a root growth inhibitor). The inhibitor prevents elongation of laterial roots until after planting. In greenhouse trials, the inhibited laterals resumed growth very rapidly after planting, and root development continued like that of naturally established trees.

139. BURDETT, A.N. New methods for measuring root growth capacity: their value in assessing lodgepole pine stock quality.
Canadian Journal of Forest Research, 1979, 9(1): 63-67
10 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.3
CAB: 1244820

The survival of lodgepole pine (Pinus contorta) planted in the spring under a variety of conditions was closely related to its root growth capacity as measured by two newly developed methods. One method employed a displacement technique to measure the root volume of test seedlings nondestructively at the beginning and end of a period of growth under standard conditions: the change in root volume was taken as a measure of root growth capacity. The other method was to record, by means of a semiquantitative scale, the number of newly elongated roots possessed by test seedlings after a 1-week period of growth under standard conditions. Similar results were obtained in tests of the latter type run at two widely differing temperatures (30 deg. C (30 deg. C day/25 deg. C night), and a constant temperature of 15 deg. C).

140. CARLSON, L.W. The effect of defoliation on conifer seedling root initiation.
Bi-monthly Research Notes, 1977, 33(1): 1
4 ref.
Subject Codes: 5.0
CAB: 806499

Dormant 2+0 lodgepole pine (Pinus contorta var. latifolia) and 3+0 white spruce (Picea glauca) were grown for 30 days in a greenhouse after various percentages of the foliage had been removed by taking off the needles (pine) or by cutting off the tops (spruce). Defoliation of pine resulted in fewer new roots per plant when 50% of the needles were removed, and in both fewer new roots per plant and fewer plants with new roots when all the needles were removed. Root initiation of white spruce was significantly increased by a 25% reduction in foliage, and only 75% defoliation resulted in significantly fewer roots per plant; this difference in response may be due to the different method of defoliation used.

141. CLINE, M.L., REID, C.P.P. Seed source and mycorrhizal fungus effects on growth of containerized Pinus contorta and Pinus ponderosa seedlings.
Forest Science, 1982, 28(2): 237-250
25 ref.
Subject Codes: 1.4, 7.3
CAB: 1557029

Seedlings from 10 provenances were inoculated with the ectomycorrhizal fungi Pisolithus tinctorius, Suillus granulatus or Rhizopagon luteolus in the greenhouse. Provenances differed significantly in their ability to form mycorrhizae with different fungi. P. contorta seedlings showed high levels of infection, which were nonlinearly and positively correlated with total dry weight for S. granulatus and P. tinctorius treatments. Formation of mycorrhizae with these species was nonlinearly and negatively correlated with P. contorta root/shoot ratios. P. ponderosa seedlings showed low levels of infection for all treatments and no correlation between infection and dry weight. From authors' summary.

142. COUTTS, M.P. Tolerance of tree roots to waterlogging 5. Growth of woody roots of sitka spruce Picea-sitchensis and lodgepole pine Pinus-contorta in waterlogged

soil.
New Phytol., 90(3), 1982: 467-476
Subject Codes: N/A
BIO: 74042435

Rooted cuttings of P. Sitchensis and P. contorta were grown with split roots in plastic troughs of soil, to produce 500 mm long woody roots on either side of each plant with the distal parts of the root system growing out into pots at the ends of the troughs. Some roots of primary structure were present in the troughs. The soil in the trough on one side of the plant was waterlogged while all other parts of the root system remained in freely drained soil. The waterlogging treatment was applied out of doors from April to Nov. In both species all roots of primary structure in the waterlogged soil were killed, whereas most of the woody roots survived. In the pine, radial growth of the waterlogged part of the woody root was reduced relative to the freely drained control side and the root tapered from the plant stem towards the center of the waterlogged zone, then increased again towards the distal end. Growth of pine roots of primary structure in freely drained soil at the distal end of the waterlogged woody root was not reduced compared with the control side. Spruce was more sensitive and growth of xylem and phloem of the woody root almost ceased at the center of the waterlogged zone; there was a carry-over effect of the waterlogging treatment into other parts of the root system. Growth of the woody root proximal to the waterlogged zone and of the primary roots distal to it were reduced. Enlarged lenticels became abundant on the woody roots of both species at the ends of the waterlogged zone and their frequency decreased towards the center. Differences in 02 transport known to occur in woody roots of the 2 spp. are discussed.

143. COUTTS, M.P., PHILIPSON, J.J. Tolerance of tree roots to waterlogging. Part 1: survival of Sitka spruce and lodgepole pine.
New Phytol., 1978, 80(1): 63-70
Subject Codes: 2.11, 8.8.3
BIO: 66002251

Rooted cuttings of Sitka spruce (Picea sitchensis) and lodgepole pine (Pinus contorta) were grown in Perspex tubes of peat and the lower portion of the root systems was flooded, while either active or dormant, and at 6 deg. and 15 deg. C. Root survival was assessed after draining the tubes. Root elongation in both species stopped within a few days of flooding, during which the 02 flux in the peat had declined to zero. Actively growing root tips were more susceptible to waterlogging than the region behind the tip and the latter region remained alive for up to 90 cm below the water-table in certain treatments. Growing roots of pine were more tolerant to waterlogging than spruce, when assessed in terms of the survival of both the tip and the basal region of the root. By contrast, dormant roots of both species were so tolerant to waterlogging that the tips remained alive and rapid regrowth took place after the soil was drained.

144. COUTTS, M.P., PHILIPSON, J.J. Tolerance of tree roots to waterlogging. Part 2: adaptation of spruce and lodgepole pine to waterlogged soil.
New Phytol., 1978, 80(1): 71-78
Subject Codes: 2.11, 8.8.3
BIO: 66002252

A study is presented of the growth of rooted cuttings of lodgepole pine (Pinus contorta) and Sitka spruce (Picea sitchensis) into waterlogged soil. Lodgepole pine roots penetrated to depths of 20 cm at 10 deg. C in soil devoid of 02, whereas Sitka spruce made only shallow growth into the water-table. The growth rate of the pine roots decreased with depth below the water-table and penetration was greater at 10 deg. C than at 20 deg. C. Large gas-filled cavities were found in the stele of the pine roots that penetrated the water-table but were absent from the spruce. When pine roots were allowed to grow into a water-table for 2 cm, and were subsequently inundated to a depth of 10 cm, root tip survival was much better than where non-acclimatized roots were flooded. The deeper penetration of waterlogged soil by lodgepole pine than Sitka spruce was due to internal 02 transport in the pine roots. 02 transport and other possible mechanisms for growth and survival of roots in waterlogged soil are discussed.

145. COUTTS, M.P., PHILIPSON, J.J. The influence of mineral nutrition on the root development of trees. Part 3: plasticity of root growth in response to changes in the nutrient environment.
J. Exp. Bot., 26(106), 1977: 1071-1075
Subject Codes: 3.3
BIO: 65036082

Lodgepole pine (Pinus contorta) seedlings were grown in solution culture with their root systems divided between 2 contrasting nutrient regimes; a high regime which provided near optimum conditions for growth, and a low regime in which nutrients were limiting. The high nutrient regime stimulated root growth whereas the roots receiving a low level of nutrients grew comparatively slowly and in certain instances stopped elongating and became brown. After differential root growth was induced, certain plants were transferred to a uniform high nutrient environment and the previously deprived parts of the root system responded by renewed growth and their growth rate increased in comparison with roots which remained in low nutrient conditions. Apparently initial nutritional differences in the environment do not lead to dominance in certain roots; the root system remains remarkably plastic.

146. CRAWFORD, R.M.M. Tolerance of anoxia and the regulation of glycolysis in tree roots. IN: Proceedings of a Conference on Physiological Genetics of Forest Tree Yield. Gorebridge, Scotland, July 13-21, 1975. XVII + 567 pp.
Academic Press, London, England, 1976: 387-401
Subject Codes: N/A
BIO: 15001313

147. CRAWFORD, R.M.M., BAINES, M.A. Tolerance of anoxia and the metabolism of ethanol in tree roots.
New Phytol., 79(3), 1977: 519-526
Subject Codes: 2.11, 8.8.3
BIO: 65048747

Ethanol can always be detected in the trunks and roots of forest trees and in the roots of pot-grown tree-seedlings under both flooded and unflooded conditions. The constant presence of this anaerobic product indicates that tree-roots and trunks exist continually in a state of total or partial anoxia. In forest trees the ethanol content at the base of the tree trunk was correlated significantly with that found in the roots and fluctuated throughout the year, reaching a maximum in winter and early spring. The highest values were noted in trees exposed to the greatest amount of flooding. Pot-grown trees of simultaneous increase in root ethanol content when placed in unaerated water culture. In the flood-intolerant P. sitchensis, anoxia induced a 12-fold increase in ethanol and this attained 5 .mu.mol g-1 fresh weight, while over the same period the ethanol in the roots of the flood-tolerant P. contorta increased only 3-fold to 0.7 .mu.mol g-1 fresh weight. These species provide another example of flooding tolerance found in association with the ability to limit ethanol production.

148. DANGERFIELD, J.A., WESTLAKE, D.W.S., COOK, F.D. Quantitative assessment of the bacterial rhizosphere flora of Pinus-contorta-var-latifolia.
Can. J. Microbiol., 21(12), 1975: 2034-2038
Subject Codes: N/A
BIO: 61028852

149. DANGERFIELD, J.A., WESTLAKE, D.W.S., COOK, F.D. Characterization of the bacterial flora associated with root systems of Pinus contorta var. latifolia.
Can. J. Microbiol., 1978, 24(12): 1520-1525
Language: en
Summary Languages: fr
Subject Codes: N/A
LISC: 281972

Root systems of young and mature lodgepole pine (P. contorta Dougl. var. latifolia Engelm.) were removed from forest stands and the associated aerobic bacterial flora isolated. Characterization of rhizoplane and control soil isolates from these tree root systems demonstrated differences from that reported for agricultural crops. Ammonifying, proteolytic and amylolytic organisms were proportionately reduced within the rhizoplane. The rhizoplane organisms grew more slowly than the control soil isolates, although they responded in greater numbers to the addition of an amino acid supplement to the growth media. The rhizoplane organisms also showed an increased ability to solubilize phosphate. The chitinolytic organisms were suppressed within the rhizoplane of the mature tree but were stimulated by the young trees. With this exception, the rhizoplene microflora of older and younger trees were similar.

150. FARRELL, E.P., MULLEN, G.J. Rooting characteristics of Picea-sitchensis and Pinus-contorta on blanket peat in Ireland.
J. Life Sci. R. Dublin Soc., 1(1), 1979: 1-12
Subject Codes: 3.6
BIO: 72045016

Rooting characteristics of 11 yr old P. sitchensis and P. contorta were examined on a blanket peat site in western Ireland. Over 40% of all roots observed were in the plow ribbon and density of rooting was greatest in this zone. Rooting density was greater in P. sitchensis than in P. contorta. This was particularly evident in the case of the finer roots. There was no difference in rooting depth between species. Effective rooting depth was 40 cm below bog surface. A relationship between water table depth and rooting density was established; the closest association existed between rooting density in the plow ribbon and water table depth. The restriction of vigorous rooting to the plow ribbon and the top 20 cm of the peat justify concern expressed about the stability of tree crops on peat sites in this region.

151. HACSKAYLO, E. Physiology, Congress Group 1. IN: Proceedings, Div. II (Forest plants and forest protection), XVI IUFRO World Congress, Oslo, Norway, June 20 to July 2, 1976.
As, Norway; IUFRO, 1976: 16-124
Language: en
Summary Languages: de, fr
Subject Codes: 3.3
CAB: 892233

Many articles written by various authors including an article on the plasticity of the growth of tree root systems in response to changes in the nutrient environment.

152. HOVLAND, J., ABRAHAMSEN, G. Acidification experiments in conifer forest. 1. Decomposition of cellulose and wood material.
Intern. Rapport, sur Nedboers Virkning pa Skog og Fisk, 1976: No. IR 27/76, 16 pp.
15 ref.
Language: no
Summary Languages: en
Subject Codes: 6.5
CAB: 1146794

In young stands of Norway spruce, Scots pine and lodgepole pine, pure cellulose and aspen sticks were placed in experimental plots in September, 1974 and decomposition was measured (as wt. loss) in September, 1975. Application of acid water (pH 2.0-6.0) by itself did not affect the rate of decomposition in 3 experiments; in a 4th experiment, 50 mm/month of water at pH 2.5 significantly increased the rate of decomposition; this effect was counteracted by application of acid rain, especially at pH 3.0 or less.

153. KETCHIE, D.O., LOPUSHINSKY, W. Composition of root pressure exudate from conifers.
Pacific Northwest Forest and Range Experiment Station, Research Note PNW- 395, 1981: 6 pp.
8 ref.
Subject Codes: N/A
RCA: X1113

Root pressure exudates collected from detopped seedlings of Douglas-fir, grand fir, noble fir, Pacific silver fir, ponderosa pine, lodgepole pine, and Engelmann spruce were analyzed for sugars, amino acids, organic acids, nitrogen, potassium, calcium and magnesium.

154. LARGENT, D.L. Mycorrhizal fungi shared by Pinaceae and Ericaceae in California.
Project CALZ00048, California State Univ., Humboldt, CAL, 27 Oct 77 to 30 Sep 79
Subject Codes: 6.2
CRIS: 0073796

Objectives: Thoroughly investigate the mycorrhizae relationships between various

ericaceous plants and different conifer species associated with such plants. Approach: Phase one will survey the Arctostaphylos species to determine which share mycorrhizae with conifers. Phase two will sample various sites to collect, identify and store fruiting bodies, establish pure culture of the funal symbiont and describe the site types. Progress: Completed: a survey of the type of mycorrhizae found on 480 plants representing twenty-seven taxa in the Ericaceae and five taxa in the Pyrolaceae has been completed. Results from this survey have been submitted for publication. Also a comparison of the mycorrhizae formed by Amanita gemmata with Arctostaphylos manzanita and with Pinus contorta. This study has been accepted for publication. A study of the type of mycorrhiza formed by several pyrolaceous hosts located in the subapline regions of the Klamath Mountains has been completed. The data awaits inclusion into the first draft of a master's thesis by Carl Wishner. This data, if finished, will be presented as the final progress report for this grant.

155. LARGENT, D.L., SUGIHARA, N., BRINITZER, A. Amanita gemmata, a non- host-specific mycorrhizal fungus of Arctostaphylos manzanita.
Mycologia, 1980, 72(2): 435-439
11 ref.
Subject Codes: N/A
CAB: 1280029

This paper represents the first report of a fungal species, Amanita gemmata forming an ectendomycorrhiza with the ericaceous plant Arctostaphylos manzanita. It also supports the non-host-specificity of the mycorrhizal fungi of ericaceous plants by demonstrating the ability of A. gemmata to form ectomycorrhiza with Pinus contorta.

156. LINDSTROM, A. Root deformation in different types of plant growing systems and possibilities of reducing root deformation.
Translation, Environment Canada, 1978, No. 00ENV TR-1710: 93 pp.
48 ref., 4 pl.
Subject Codes: 7.3
CAB: 1499744

Transl. from Rapporter och Uppsatser, Institutionen for Skogsforyngring, Skogshogskolan, Sweden, (1978) No. 91, 95 pp. Limited distribution.

157. LONG, J.N. Root system form and its relationship to growth in young planted conifers. IN: Proceedings of the root form of planted trees symposium, Victoria, B.C., May 16-19, 1978.
Ministry of Forests & Canadian Forest Service, 1978: 222-234
28 ref.
CAB: 1146849

Root systems of conifers growing in Oregon and Washington were excavated 4 to 7 years after planting out. Root form is described for Douglas-fir, western hemlock, noble fir (Abies procera), ponderosa pine and lodgepole pine, of stock types: direct sown (controls); containerized; and 2+0, 1+1, and 2+1 bare-root stock. Root coiling occurred in containerized stock to a greater extent in smooth-walled than ribbed containers. Deformation of the roots associated with planting practices was common for bare-root stock, but rare for containerized stock. The root systems of planted trees were more constricted than those of trees from seed, and the taproot development was restricted.

158. LOPUSHINSKY, W. Occurrence of root pressure exudation in Pacific Northwest conifer seedlings.
Forest Science, 1980, 26(2): 275-279
12 ref.
Subject Codes: 7.3
BIO: 71005995

Exudation was observed from the stumps of detopped seedlings of Pseudotsuga menziesii, Abies grandis, A. procera, A. amabilis, Pinus ponderosa, P. contorta, Picea engelmanni and Larix occidentalis. Exudation occurred both from seedlings with completely suberized root systems and from seedlings with various amount of new root growth, and persisted up to 79 days. Exudate osmotic potentials were -0.24 to -0.78 bar. Long-term cold storage of the seedlings is thought to be the major factor stimulating exudation in these seedlings.

159. MCMINN, R.G. Root development of white spruce and lodgepole pine seedlings following outplanting.
Ministry of Forests & Canadian Forest Service, 1978: 186-190
4 ref., 1 pl.
Subject Codes: 7.3, 7.4
CAB: 1107348

Root development was studied for bare-root and container-grown plants for 5 years after planting out in: untreated; blade-scarified; and mixed treatment sites. Root mass was greatest in sites where duff had been incorporated into the underlying mineral soil. Container stock had substantially more root mass than bare-root stock in untreated sites. Differences in root form were relatively small.

160. MARX, D.H. (Compiler): Amino acid inhibition analysis of lodgepole pine ectomycorrhizae. IN: Third N. American Conference on Mycorrhizae.
Athens, Georgia, U.S.A., Institute of Mycorrhizal Research & Dev., SW Forest Experiment Stn., 1977: 86
Subject Codes: N/A
CAB: 1315990

A study of the transport of 14C-amino acids between host and mycorrhizae.

161. MEXAL, J.G. Water relations of ectomycorrhizas of lodgepole pine.
Dissertation Abstracts International, B, 1975, 36(1): 113
Subject Codes: N/A
CAB: 546479

The effect of artificially induced water stress on physiological processes was studied with polyethylene glycol 400 as the osmotic agent. Four species of mycorrhizal fungi were grown in culture at different water potentials (W). The values of W at which optimum growth occurred ranged from 0 to -15 bars. Seed germination of Pinus contorta was not influenced when W was no lower than -8 bars, but seedling weight and length at 30 days were reduced when W was lower than -2 bars. Seedling growth at W ranging from 0 to -6 bars was not inhibited after 2.5 weeks of water stress, but growth was inhibited after 11 weeks of stress. After water stress for 30 weeks, growth was seriously affected by reduced W and species of fungus used as mycorrhizal inoculum. Mycorrhizae did not form at -4 and -6 bars. Roots of 7-year-old P. contorta exuded more material at a stress of -4 bars than at stresses of 0 or -2 bars. Exudation of material did not differ between mycorrhizal and non-mycorrhizal roots.

162. MEXAL, J.G., REID, C.P.P., BURKE, E.J. Scanning electron microscopy of lodgepole pine roots.
Plant Cell Physiol., 1979, 20(6): 318-323
Subject Codes: N/A
LISC: 449212

The mycorrhizas of Pinus contorta and known fungal symbionts were examined with scanning electron microscopy. Fungal symbionts included Cenococcum geophilum, Thelephora terrestris, Pisolithus tinctorius, and Rhizopogon vinicolor, as well as mychorrhizas formed with unknown symbionts. The technique used resulted in minimal shrinkage of plant tissue and clearly elucidated the morphology of fine roots. The roots of P. contorta possess few root hairs, apparently relying on mycorrhizal associations for nutrient uptake. Fungal mantles varied with symbionts from smooth, with no hyphae emanating from the mantle, to mantles with long hyphae growing into the rhizosphere.

163. MOLINA, R. Ectomycorrhizal inoculation of containerized Douglas-fir and lodgepole pine seedlings with six isolates of Pisolithus tinctorius.
For. Sci., 1979, 25(4): 585-590
Subject Codes: 6.2
LISC: 459256

Containerized Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus

contorta) seedlings grown under lowered fertility were inoculated with vegetative mycelium from 6 isolates of P. tinctorius. The isolates differed both culturally and in effectiveness as ectomycorhizal inoculum. The percent of seedlings successfully inoculated and percent of feeder roots colonized differed significantly among the isolates. Analysis of variance, however, for seedling height, stem diameter, stem and root dry weights, and top root ratio showed no significant differences between any inoculation treatment and controls for either tree species. This study reinforces the concept that a wide array of fungus ecotypes should be tested before a specific strain is selected for wide-scale nursery inoculations.

164. MOLINA, R. Ectomycorrhizal inoculation of containerized western conifer seedlings.
Res. Note, Pacific NW For. and Range Exp. Stn., 1980, PNW-357: 10 pp.
Subject Codes: N/A
LISC: 545116

Of 15 ectomycorrhizal fungi inoculated onto 5 container-grown conifer species (Larix occidentalis, Pinus contorta, P. ponderosa, Pseudotsuga menziesii, and Tsuga heterophylla), only Laccaria laccata and Cenococcum geophilum consistently formed ectomycorrihizae on all conifer hosts. Percents of mycorrhizal feeder roots were generally high, ranging from 86 on L. occidentalis to 94.5% on T. heterophylla for L. laccata and from 48.1 to 81.8% on these respective hosts for C. geophilum. L. laccata significantly colonized more feeder roots than C. geophilum for most conifer species. Only P. menziesii seedlings inoculated with C. geophilum were significantly larger than controls. There is a need for further studies with a wider range of fungi.

165. MOLINA, R., TRAPPE, J.M. Patterns of ectomycorrhizal host specificity and potential among Pacific NW conifers and fungi.
Forest Science, 1982, 28(3): 423-458
62 ref., 9 pl.
Subject Codes: N/A
CAB: 1570092

Twenty-seven species of fungus, isolated 1974-1977, were tested for ectomycorrhizal formation with 7 conifer species: Pseudotsuga menziesii; Tsuga heterophylla; Larix occidentalis; Picea sitchensis; Pinus contorta; P. ponderosa; and P. monticola. Aseptically-raised seedlings were inoculated with fungus culture and examined after 6 months. The percent of short roots colonized was determined visually, and cross- placed in 3 groups: (a) fungi with wide mycorrhizal host potential, low specificity, and sporocarps usually associated with diverse hosts in the field; (b) fungi with intermediate host potential, but limited or specific in sporocarp-host associations, and (c) fungi with narrow host potential, only able to form ectomycorrhizae with a specific host species, or species within a genus and limited in their sporocarp association. Many group (b) species were able to form well-developed mycorrhizae with one or more non-associated hosts. The 3 Pinus spp. showed little infrageneric differences in their ability to form mycorrhizae with the various fungi. Pseudotsuga menziesii and L. occidentalis were able to form mycorrhizae with fungi that fruit only with one or the other. Group (a) fungi showed no incompatibility with any hosts; it is suggested that they share a compatibility or recognition factor common to many mycorrhizal hosts. Type (c) fungi often showed incompatibility with non-associated hosts. The most common indicators of incompatibility were disruption of the new cortex by the fungi and lignification, suggesting a phenolic defence mechanism.

166. NOBLE, D.L. Roots of (direct sown) lodgepole pine seedlings reach depth of only 3 to 4 inches their first season (in central Colorado Rockies).
Research Note, Rocky Mountain Forest and Range Experiment Station, USDA For. Service, 1979, No. RM-363: 3 pp.
7 ref., 1 pl.
Subject Codes: 4.2

CAB: 1472341

167. OGAWA, M. Microbial ecological of "Shiro" in Tricholoma matsutake and its allied

species IX. Tricholoma ponderosum in Pseudotsuga menziesii-Tsuga heterophylla and Pinus contorta forests.
Transactions of the Mycological Society of Japan, 1979, 20(3): 370-382
17 ref., 6 fig.
Language: ja
Summary Languages: en
Subject Codes: N/A
CAB: 1256074

T. ponderosum occurs on these hosts in the coniferous forests of northern USA and southwestern Canada, forming fruitbodies in fairy rings. The mycorrhizae formed on the fine roots were black and elongated with numerous roots being covered by mycelium but no development of a fungal sheath or Hartig's net typical of ecomychorrhizae. The fungus may be distinguished morphologically from T. matsutake and T. caligatum by the white colour of the fruitbodies but all 3 spp. are very similar.

168. PHILIPSON, J.J., COUTTS, M.P. Tolerance of tree roots to waterlogging. Part 3: oxygen transport in lodgepole pine and Sitka spruce roots of primary structure.
New Phytol., 80(2), 1978: 341-350
Subject Codes: 2.11, 8.8.3
BIO: 66030084

Seedling root systems, or individual roots of cuttings, were submerged in reduced indigo-carmine solution so that only the seedling shoot, or basal part of the cutting root, was exposed to air or 02. 02 diffusing out of the roots produced a localized blue coloration of the previously clear reduced dye; this process was employed for studying internal 02 movement. Using plants grown in freely drained soil it was evident that seedlings of the flood-tolerant species, lodgepole pine (Pinus contorta) had a greater capacity for 02 transport than the flood-intolerant Sitka spruce (Picea sitchensis). 02 diffusion was also observed in roots detached from lodgepole pine cuttings and was greatly enhanced in plants which had grown in waterlogged conditions; in the latter plants 02 diffusion was detected from the root tips after a short exposure of the basal region of the root to 02, whereas roots from plants grown in freely drained soil showed diffusion of 02 only from the upper submerged portion during the same treatment period. 02 diffusion over distances of more than 30 cm was detected in certain experiments. Observations on the movement of gas supplied under pressure to lodgepole pine root segments showed that the rate of gas flow was much greater in roots grown in waterlogged soil than in those grown in freely drained soil and that the gas movement occurred in the stelar tissues. The regions of 02 entry included the needles, and lenticels on the roots.

169. PHILIPSON, J.J., COUTTS, M.P. Tolerance of tree roots to waterlogging. IV. Oxygen transport in woody roots of Sitka spruce and lodgepole pine.
New Phytol., 1980, 85(4): 489-494
Subject Codes: 8.8.3
LISC: 553180

Internal 02 movement was demonstrated in woody roots of both Picea sitchensis and Pinus contorta by partially submerging detached roots in reduced indigo-carmine solution and noting the appearance of the blue halo due to re-oxidisation of the dye. Transport in the flood-tolorant pine occurred in both wood and bark and was greater than that in spruce where it was confined to the bark. The pathways of 02 movement within the tissues are discussed and the results are considered in relation to the survival of tree roots when waterlogging of both primary and woody roots occurs.

170. REID, C.P.P. Soil fertility and light intensity effects on Pinus root carbohydrate allocation and ectomycorrhizae.
Project COLZ00512, Colorado State Univ., Fort Collins, COL, 01 Oct 82 to 30 Sep 84
Subject Codes: 3.3
CRIS: 0083092

Objectives: Determine if photosynthetic rate and dry matter increases due to mycorrhizae formation are related to phosphorus increase, nitrogen increase, or the interaction of the two. Determine if early inoculation and mycorrhizae formation stimulate early phases of growth by improving phosphorus nutrition. Determine if root and shoot and shoot growth patterns during the first growing season are under endogenous controls, and if so, determine if such growth patterns can be correlated with distinct morphological changes or phosphorus, nitrogen and

carbohydrate content. Determine how mycorrhizae formation influences such endogenous control. Approach: Seedlings of Pinus contorta, grown in containers in a high light intensity at intermediate levels of N and P for 5 weeks, after which time they will be analyzed for photosynthetic rates, stomatal conductance, shoot and root biomass, and root and shoot P and N content. Following this 5 week period, other seedlings will be subjected to 4 levels of N and 4 levels of P in a factorial design and grown for an additional 7 weeks. Mycorrhizae fungal inoculation will be considered as one level of N and one level of P. At the end of the 7 week period, the same parameters will be measured as at 5 weeks. Progress: Lodgepole pine (Pinus contorta) seedlings were grown from March through August 1981 in a modified Hocking's nutrient solution under three nitrogen regimes and at three light intensities. The seedlings were inoculated with the ectomycorrhizal fungi Suillus granulatus and Pisolithus tinctorius after 10 weeks of seedling growth. Growth parameters (e.g. dry matter, root/shoot ratios, etc.), N and P content of foliage and net photosynthetic rates were determined at 5 and 10 weeks (prior to inoculation) and at 16 weeks (6 weeks after inoculation). Root samples were collected at the end of 10 and 16 weeks for analysis of root carbohydrates. Mycorrhizal development on seedling roots was determined at the final harvest date (16 weeks). Analysis of growth parameters and photosynthetic measurements are currently in progress. Root carbohydrate determination awaits standardization of the thin-layer and gas-liquid chromatography methods currently under development (two graduate students are conducting thesis research on this project).

171. REID, C.P.P., MEXAL, J.G. Water stress effects on root exudation by lodgepole pine.
Soil Biology and Biochemistry, 1977, 9(6): 417-421
27 ref.
Subject Codes: N/A
CAB: 1118837

Individual roots of a 7-year-old lodgepole pine from the Rocky Mountains, transplanted into vermiculate/peat moss in a greenhouse, were subjected to water potentials of (a) 0, (b) -200, and (c) -400 kPa in tubes of aerated nutrient soil, containing PEG 4000 as osmotic agent. Root exudation of photoassimilated 14CO2 by unbranched non- mycorrhizal roots ("mother roots"), and by lateral roots with various degrees of short- root mycorrhizal infection, was followed for 10 days after exposing the shoot to a single dose of 14CO2. Results were n.s.d. between (a), (b) and (c) nor between mycorrhizal and non-mycorrhizal roots, probably owing to high variability and small sample sizes. However, the results show that 30-50% of the total 14C-labelled assimilates that had moved into the roots were exuded during the 10 days (but mainly on the 3rd day), and that the proportion of 14C assimilates that were translocated to the roots increased from (a) to (c).

172. REID, C.P.P., NISHIJIMA, W.T. Classification, identification & distribution of lodgepole pine ectomycorrhizae in the Rocky Mountains.
Project COLZ05352, Colorado State Univ., Fort Collins, COL, 01 Oct 78 to 30 Sep 80
Subject Codes: 6.2
CRIS: 0075543

Objectives: Characterize the ectomycorrhizae of lodgepole pine (Pinus contorta Dougl.) on the basis of simple morphologica, physical and histological characteristics. Identify the fungal symbiont associated with each type of lodgepole pine ectomycorrhizae. Develop a key based on the above characteristics for use in the identification of ectomycorrhizae associated with lodgepole pine. Determine the frequency and distribution of the different types of lodgepole pine ectomycorrhizae that occur at various elevations in the Rocky Mountain Region. host species to reveal their true, natural affinities. Root and sporophore samples will be collected from four different stands of lodgepole pine. Several soil and sporophore samples will be taken along transects running through each stand. A series of simple list-count quadrats will be established throughout the stand. Species of sporophores within these quadrats will be recorded and their numbers determined by count. Collection will also be made throughout the length of each transect. Progress: Mycorrhizal roots were collected from lodgepole pine seedlings at five geographical locations in the Front Range of the Colorado Rocky Mountains representing elevations from 8,500 ft. to 10,000 ft., and totalling 52 individual trees. Mycorrhizae were planted out on nutrient agar and suspected mycorrhizal fungi isolated and maintained in culture. Isolates of known ectomycorrhizal fungi were grown for comparison of culture characteristics. Suspected mycorrhizal fungi were then inoculated into axenic cultures of lodgepole seedlings germinated from surface sterilized seed using several cultural systems. Success of mycorrhizal formation was then assessed after 6 months. Very few of

the isolated fungi formed mycorrhizae under the established culture conditions (less than 3%). Difficulties with axenic establishment led to investigating use of gentamicin as a bacteriocide. Fifty ppm of gentamicin proved effective in killing bacteria without detrimental effects on mycorrhizae or pine roots (as determined by respiration and growth rates). Two fungal species were selected for assessment of cytokinin production in pure culture and in symbiosis with a pine host. One fungus (Pisolithus tinctorius) which produced cytokinins in pure culture also enhanced the level of cytokinins (ca. 1.5X) found in the foliage of its pine host as compared to pine without mycorrhizae.

173. RIEDACKER, A., GAGNAIRE-MICHARD, J. (Editors) Absorption of ammonium and nitrate by mycorrhizal and non-mycorrhizal roots of pine.
Dept. For. and Wood Sci., Colorado State Univ., Fort Collins, INRA-CNRF, 1978: 336-345
23 ref.
Subject Codes: 3.3
CAB: 1273031

The absorption of NH4 and NO3 ions by mycorrhizal and non-mycorrhizal roots of 1-yr- old lodgepole pine, ponderosa pine and loblolly pine seedlings was studied. Fungal symbients included Pisolithus tinctorius and Thelephora terrestris. An initial rapid ion uptake was followed by a levelling-off of the absorption curve. Time required to reach saturation varied with species. Saturation levels for non-mycorrhizal roots were significantly different in both NH4 and NO3 uptake. Ponderosa pine exhibited the greatest absorption of both ions, while the greatest differential in absorption ratio was found with loblolly pine. Mycorrhizae showed greater absorption of both ions than non- mycorrhizal roots for all species. Differences between fungal species were small for both ions, but P. tinctorius mycorrhizae showed a more efficient uptake system. From authors' summary.

174. SANDERSON, P.L., ARMSTRONG, W. Soil waterlogging, root rot and conifer windthrow: oxygen deficiency or phytotoxicity?
Plant and Soil, 1978, 49(1): 185-190
Subject Codes: 2.11, 3.6
LISC: 092940

Phytotoxins have been monitored in peaty forest soils subject to waterlogging. The effect in solution culture of these phytotoxins on Sitka spruce (Picea sitchensis) and lodgepole pine (Pinus contorta var. latifolia) cuttings has been studied and compared with the effects of anoxia. The relative significance of these factors in the field situation is discussed and a possible relationship between root ventilating power and response to soil waterlogging is outlined.

175. SANDERSON, P.L., ARMSTRONG, W. The responses of conifers to some of the adverse factors associated with waterlogged soils.
New Phytol., 85(3), 1980: 351-362
Subject Codes: 2.11, 8.8.3
BIO: 71005609

The effect in solution culture of iron (II), acetic and butyric acids and ethylene on rooted cuttings of Sitka spruce (Picea sitchensis (Bong.) Carr) and lodgepole pine (Pinus contorta Dougl.) was studied and compared with the effects of anoxia. A relative growth rate parameter is employed to reveal changes in the rate of root growth. Possible mechanisms of toxicity and detoxification are suggested and the greater tolerance of lodgepole pine is discussed in relation to its superior gas transport system. Conclusions are drawn concerning the role played by each of the toxic factors in the field situation.

176. STEFANSSON, E. Root quality of pine plantations established with seedlings grown in multipots. IN: Proceedings of the Root Form of Planted Trees Symposium, Victoria, B.C. May 16-19, 1978.
Ministry of Forests & Canadian Forest Service, 1978: 114-118
1 pl.
Subject Codes: 7.3
CAB: 1107355

In a detailed study of the root systems of Scots pine and lodgepole pine planted from multipots in Sweden since 1967, a method for quantitatively evaluating the

quality of root systems was devised. The percent of plants in each of the following classes is assessed: perfect root system; slightly tangled roots; tangled but in all probability harmless; risk of strangulation, fracture or toppling; and certainty of failure. A "risk taking" is then obtained for each plantation. Some detailed account was published in Swedish in Sveriges Skogsvardsforbunds Tidskrift (1978) 76, 269-304.

177. TRAPPE, J.M. Differential effects of mycorrhizal fungi on conifer response to acid rain.
Project ORE-FS-120-S, Oregon State Univ., Corvallis, ORE, 11 Mar 80 to 31 Dec 81
Subject Codes: 3.6, 6.5
CRIS: 0081470

Objectives: The purpose of this project is to quantify effects of differential mycorrhizal fungi that enhance tolerance most effectively. Approach: Research will be performed on the evaluation and selection of fungi that best tolerate acid rain. It will include their inoculation on hosts for comparing host x fungus interactions to a range of soil acidities under carefully controlled conditions and testing the best combinations under experimental acid rain. Sequential experiments will proceed as follows: Determine pH tolerances of mycorrhizal fungi and determine effects of mycorrhizae on response of Douglas-fir, western hemlock, ponderosa pine and lodgepole pine seedlings to acid rain. Progress: Different species of mycorrhizal fungi and different isolates of selected species responded to Ph differences in vitro in very different ways. Some isolates maintained high growth rates over a span of 4 pH units, a character important for nursery inoculation success. Other isolates showed pronounced growth peaks at one pH and hypothetically would not be widely adaptable to a range of pH's in nursery or forest soils. One manuscript has been submitted for publication.

178. VAN EERDEN, E. Roots of planted trees in central British Columbia. IN: Proceedings of the Root Form of Planted Trees Symposium, Victoria, British Columbia, May 16-19, 1978. Session C: Sub-boreal Canada and Inland United States.
Ministry of Forests & Canadian Forest Service, 1978: 201-208
3 ref., 2 pl.
Subject Codes: 7.3, 7.4
CAB: 1107351

Observations from several trials indicated that root form of container-grown stock was determined by container design, and root form of bare-root stock was determined by planting method. The formation of "J-roots" was common in bare-root stock. Roots of container stock typically had an enlarged central core, which was often spiralled in lodgepole pine. The risk of toppling, though small, is expected to be reduced by improving container design and/or root pruning.

179. WOODMANSEE, R.G. Variability in Colorado mountain soils.
J. Colo-Wyo. Acad. Sci., 1972, 7(2-3): 24 pp.
Subject Codes: N/A
BIO: 73004743

180. YAVITT, J.B., FAHEY, T.J. Loss of mass and nutrient changes of decaying woody roots in lodgepole pine forests, southeastern Wyoming.
Can. J. of For. Res. Vol. 12 (4) Dec./82: 745-752
8 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
RCA: X1127

Woody root decomposition was studied in two lodgepole pine (Pinus contorta Dougl. ex Loud. ssp. latifolia (Engelm.)) stands in the Medicine Bow Mountains, Wyoming, from samples obtained beneath stumps that remained following partial cuttings and fires that originated in the present stands 80 and 110 years ago. The specific gravity of root wood declined exponentially during the first 15 years of decay. Mass-loss rates were faster for smaller than larger size classes of material, and rates were slightly faster on the site with fine textured soil than on the site with gravelly soil. Nitrogen and calcium concentrations increased in both root wood and bark after 80 years of decay. Rapid decreases in potassium and

phosphorous concentration occurred in the first 15 years of decay; however, contents increased slightly in wood in the advanced decay classes. Magnesium concentration initially increased with decay but thereafter decreased after moderate decay. Woody roots of lodgepole pine appear to persist for many years (greater than 110 years) following death of the aboveground portion of the tree, but nitrogen immobilization in decaying root wood is much less than the amount immobilized in aboveground detritus.

## 2.4 BARK

181. COLE, D.M. Within-stand comparisons of inner bark electrical resistance in lodgepole pine - the bark moisture factor.
Forest Science, 1980, 26(2): 309-312
6 ref.
Subject Codes: 5.1
CAB: 1258883

Significant seasonal changes in the electrical resistance (ER) of inner bark of 9 tagged trees in a stand in Montana accompanied corresponding changes in bark m.c. However, m.c. on a given day of measurement was not correlated with ER. Significant correlations were found for ER and phloem thickness, and ER and d.b.h. When ER was used to detect relative differences in vigour among trees of the same stand, m.c. did not require measurement and standardization if comparisons were made on the same day. From author's summary.

182. KOZAK, A., YANG, R.C. Equations for estimating bark volume and thickness of commercial trees in British Columbia.
Forestry Chronicle, 1981, 57(3): 112-115
13 ref.
Subject Codes: 5.1
CAB: 71442555

A number of logarithmic bark volume equations based on height, d.b.h., and double bark thickness at b.h. were applied to a total of 32 000 trees representing 15 species groups of different ages from different climatic zones. A simple equation with good predictive power is recommended, giving standard errors ranging from 0.0086 m3 (interior lodgepole pine) to 0.6988 m3 (coastal mature Douglas-fir). A bark taper equation is also given, for estimating bark thickness at any given height above b.h.

183. LANGE, R.W. Bark thickness - linear regression coefficient factors for 4 Montana coniferous tree species.
Mont. Forest Conserv. Exp. Sta. Note 9, 1971
Subject Codes: N/A
BIO: 71062545

184. MANNING, T.D.R. Di terpene constituents of Pinus-contorta bark.
Aust. J. Chem., 26(12), 1973: 2735-2739
Subject Codes: N/A
BIO: 58022042

185. ROWE, J.W., RONALD, R.C., NAGASAMPAGI, B.A. Terpenoids of lodgepole pine bark.
Phytochemistry, 11(1), 1972: 365-369
Subject Codes: N/A
BIO: 53069058

## 2.5 TWIGS - SHOOTS

186. BURDETT, A.N. A nondestructive method for measuring the volume of intact plant parts.
Can. J. For. Res., 9(1), 1979: 120-122
Subject Codes: 2.3, 7.3
BIO: 68067064

The volume of intact plant parts can be measured rapidly by means of a simple displacement technique. The procedure is to dip the root, shoot, or other plant part to be measured into a vessel of water standing on a top-loading balance and take the resulting change in the reading of the balance as an estimate of tissue volume. The method was capable of yielding highly reproducible measurements of conifer (lodgepole pine) seedling shoot and root volumes. One use that was made of the technique is in the nondestructive determination of the shoot:root ratio of seedlings which are subsequently to be used in growth studies. Another was in the estimation of root growth capacity from measurements of the root volume of test seedlings made both at the beginning and end of a period of growth under standard conditions.

187. CANNELL, M.G.R. Shoot apical growth and cataphyll initiation rates in provenances of Pinus contorta in Scotland.
Canadian Journal of Forest Research, 1976, 6(4): 539-556
34 ref.
Language: en
Summary Languages: fr
Subject Codes: 1.2, 1.4
CAB: 734943

Differences in the rate of cataphyll initiation were studied in 3-year-old P. contorta during one growing season. The provenances that produced most cataphylls during the season developed and maintained large apical domes. There were only slight differences between provenances in the rate at which apical domes expanded in midsummer, but greater differences were observed in spring and autumn. Differences in the projected areas of the tissues used to form new cataphyll primorida were inversely related to cataphyll initiation rates. The results indicate opportunities for increasing needle initiation rates by combining: an ability to begin apical growth early in the year, found in slow-growing Alaskan and inland British Columbian provenances; an ability to generate large apical domes, found in many coastal provenances; and a later decline in apical relative growth rate, found only in south coastal provenances.

188. CANNELL, M.G.R., THOMPSON, S., LINES, R. An analysis of inherent differences in shoot growth within some north temperate conifers.
Academic Press, London, England, 1976: 173-205
Subject Codes: N/A
BIO: 15001301

189. LANNER, R.M. Patterns of shoot development in Pinus and their relationship to growth potential. IN: Proceedings of a Conference on Physiological Genetics of Forest Tree Yield, Gorebridge, Scotland, July 13-21, 1975. XVII + 567 pp.
Academic Press, London, England, 1976: 223-243
Subject Codes: N/A
BIO: 15001303

190. THOMPSON, S. The results of recent studies into the shoot elongation and dry matter production of two contrasted provenances of lodgepole pine. IN: Pinus contorta Provenance Studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 52-58.
Subject Codes: 1.4
CAB: 1118599

191. THOMPSON, S. Some observations on the shoot growth of pine seedlings.
Can. J. For. Res., 6(3), 1976: 341-347

Subject Codes: N/A
BIO: 63020498

Sequential observations in lodgepole pine (Pinus contorta Dougl.) and Scots pine (P. sylvestris L.) showed that the 2nd season's shoot was not produced solely from stem units in the terminal resting bud as previously assumed. The stem units held in the rosette of primary needles surrounding the terminal bud elongated to form most of the 2nd season's shoot. The terminal bud only contributed 29 to 54% of the stem units. There was a marked difference between an inland and a coastal provenance of lodgepole pine in the appearance of the shoot apex at the end of the 1st growing season.

## 2.6 BUDS

192. LANNER, R.M., VAN DEN BERG, D.A. The vegetative buds and shoots of lodgepole pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 68-85
16 ref.
Subject Codes: 1.2, 2.2, 2.5
CAB: 757492

Terminal bud formation in Pinus contorta is described, including the development of needle fascicles and lateral branch buds. Mature shoot morphology is related to the morphogenetic pattern of the buds, resulting in either monocyclic or polycyclic shoots. These patterns can assist in determining the age of trees or branches. Crown shape is explained in terms of shoot growth gradients within the tree and the timing of lateral bud elongation. From authors' summary.

193. OWENS, J.N., MOLDER, M. Development of long-shoot terminal buds of Pinus contorta ssp. contorta. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 86-104
15 ref.
Subject Codes: 1.2, 2.5
CAB: 757489

The annual growth cycle of P. contorta ssp. contorta long-shoot terminal buds was studied anatomically and compared to that of P. contorta ssp. latifolia in order to establish the time and method of cone initiation.

194. VAN DEN BERG, D.A., LANNER, R.M. Bud development in lodgepole pine.
For. Sci., 17(4), 1971: 479-486
Subject Codes: N/A
BIO: 54016420

## 2.7 LEAVES

195. BOAG, D.A., KICENIUK, J.W. Protein and caloric content of lodgepole pine needles, Pinus contorta.
Forest Chron., 1968, 44(4): 28-31
Subject Codes: 8.1
BIO: 50010098

196. CARLSON, L.W., JOHNSTONE, W.D. Use of the rhizometer to estimate foliar surface

area.
Bi-monthly Research Notes, 1979, 35(2): 9
4 ref.
Subject Codes: N/A
CAB: 1299194

Rhizometer estimates were correlated with measurements by the accurate glass-bead technique. Standard curves were established for: lodgepole pine, Douglas-fir, white spruce, Colorado spruce (Picea pungens) and Siberian elm (Ulmus pumila). The rhizometer method provides a fast and reliable estimate of leaf or needle surface area.

197. LASSOIE, J.P., FETCHER, N., SALO, D.J. Stomatal infiltration pressures versus diffusion porometer measurements of needle resistance in Douglas-fir and lodgepole pine foliage.
Canadian Journal of For. Res., 1977, 7(1): 192-196
20 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.11
CAB: 769819

Stomatal infiltration pressures (inversely related to aperture) and foliar diffusion resistances, measured using an aspirated porometer were determined in a small Douglas-fir (Pseudotsuga menziesii) under controlled environmental conditions and in a large lodgepole pine (Pinus contorta var. latifolia) in the field. The infiltration technique was incapable of accurately estimating leaf resistances but was able to indicate adequately whether stomata are open or closed when the use of a diffusion porometer is impossible, e.g. under conditions of low temperature, dew or precipitation.

198. POLLACK, J.C., DANCIK, B.P. Atypical needle fascicles in Pinus contorta.
Canadian Journal of Forest Research, 1979, 9(4): 538-541
6 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1315836

Specimens of lodgepole pine with 1-5 needles per fascicle were found in Jasper National Park, Alberta, Canada. The max. % of atypical fascicles occurred at 2150 m above sea level. These trees bore significantly greater % of atypical fascicles than trees at 2000 m and 1850 m above sea level. From authors' summary.

199. VON RUDLOFF, E., NYLAND, E. Chemosystematic studies in the genus Pinus. III. The leaf oil terpene composition of lodgepole pine from the Yukon Territory.
Canadian Journal of Botany, 1979, 57(12): 1367-1370
11 ref.
Language: en
Summary Languages: fr
Subject Codes: 1.2
CAB: 1134340

Samples were analyzed from 95 trees of Pinus contorta var. latifolia from the Yukon and Northwest Territories. Terpene patterns were compared with those known for samples from the Rocky Mountains (types B and C) and with those for 30 typical trees of P. contorta var. contorta from British Columbia and Oregon (type A). Thirty-five trees, including some from nunataqs that were refuges during the last ice age, had the "coastal" type A terpene pattern. A few had the rare type C or were intermediate between A and B, or B and C.

## 2.8 CONES

200. CROSSLEY, D.I. Fruiting habits of lodgepole pine.

Can. Dep. North. Aff. and Nat. Resour., For Br., For. Res. Div., Tech. Note 35, Ottawa, Ont., 1956: 32 pp.
Subject Codes: 4.0
RCA: X1019

201. HELLUM, A.K., BARKER, N.A. The relationship of lodgepole pine cone age and seed extractability.
Forest Science, 1981, 27(1): 62-70
17 ref., 1 pl.
Subject Codes: 4.1, 4.4
CAB: 1395171

Closed cones were collected from 4 trees on each of 2 sites in 110-year old stands in Alberta in June, 1978. Ages (mostly under 16 years old) and m.c. were recorded, and sample cones were exposed to 180 deg. C in a kiln to measure the time taken to melt the resin bonds and snap the scales open. Seeds were then released by heating to 60 deg. C and tapping the cones. The values for m.c. were also tested. Only 25% of the variation in bond-breaking time was explained by cone age; initial cone m.c. accounted to 80%, the resin bonds of moist cones breaking more slowly. Resin bonds melted above 12% m.c. but cone scales did not reflex until m.c. was less than 12%. Full seed release required many hours of drying at 60 deg., and was not related to age. The last seeds to be shed from test cones were often empty (over 45% after 10h extraction). From authors' summary.

202. HELLUM, A.K., PELCHAT, M. Temperature and time affect the release and quality of seed from cones of lodgepole pine from Alberta.
Canadian Journal of Forest Research, 1979, 9(2): 154-159
28 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.1, 4.4
CAB: 1258851

Temperatures between 60.0 and 82.2 deg. C were used and cones were kept in kilns for 4, 6 and 8 hours. The cones were soaked in 50 deg C water for 5 min before being placed in the kilns. As temp. was raised from 60.0 to 82.2 deg. C, seed release from cones increased from 20% to full seed release. (Full seed release was defined as max. seed yield under given test conditions, realizing that a small but undetermined amount of seed was not released). Average germination dropped from about 85 to less than 40% over this same temp. range. The best average seed release and average germination (called seed value), approached 80% when cones were exposed to 69 deg. C for 8 hours in the kiln. From authors' summary.

203. LINHART, Y.B. Maintenance of variation in cone morphology in California, USA, closed pine cones, the roles of fire, squirrels and seed output.
Southwest Nat., 23(1), 1978: 29-40
Subject Codes: 1.2, 3.2, 4.0, 6.3, 6.6
BIO: 66013044

In the Californian (USA) representatives of the subsection Oocarpae (Pinus attenuata, P. muricata and P. radiata), (also P. Banksiana and P. contorta) there is variability in several cone characters. The cones ranged from being thin-scaled and attached to branches at relatively right angles, to having very thick scales and prominent apophyses on one side and attached to branches at acute angles. Thick-scaled cones provide more protection for the seeds from the high temperatures of fires than do thin-scaled cones and may deter attacks from the squirrels Tamiasciurus and Sciurus. These cones carry fewer seeds per given weight of cone which is energetically less efficient for the squirrels to harvest. Squirrels are known to selectively feed on cones carrying more seeds per cone. Thin-scaled cones yield more seeds per given cone weight. This is energetically advantageous to reproductive success but may make them favorite targets for squirrel feeding. Consequently, individuals with thin-scaled cones can only be favored in areas where fires are not too hot and where squirrels are rare or absent. Such conditions seem to be met for pine populations on Santa Cruz, Santa Rosa, Guadalupe and Cedros Islands; San Vicente and Ensenada, Baja California. It is precisely in these populations where cones with thin scales are most frequent. In areas where fires may be expected to be hotter and squirrels more common, individuals with thick-scaled asymmetric cones predominate.

204. NEWMAN, K.W. The interpretation of neighbourhood radii and linkage distance as used for clustering.
Taxon, 1981, 30(4): 768-778
Subject Codes: N/A
BIO: 74066417

A procedure is described for interpreting the resemblance distance between objects which are represented by points in a multidimensional space, in terms of percentile radii about these points. An illustration of the procedure (i.e., a data set consisting of measurements of 9 cone characters from 10 randomly chosen cones from 24 sites within the geographic range of Pinus contorta) demonstrated its usefulness for the recognition and analysis of innate group structure.

205. PHARIS, R.P., ROSS, S.D., WAMPLE, R.L., OWENS, J.N. Promotion of flowering in conifers of the Pinaceae by certain of the gibberellins.
Acta. Hortic. (The Hague), 56, 1976: 155-161
Subject Codes: N/A
BIO: 77012753

206. SMITH, C.C. The facultative adjustment of sex ratio in lodgepole pine, Pinus-contorta.
Am. Nat. 1981, 118(2): 297-305
Subject Codes: 4.0
BIO: 22004955

207. WEIR, G.H., THURSTON, E.L. Scanning electron microscopic identification of fossil Pinaceae pollen to species by surface morphology.
Palynology, 1977, (1): 157-165
Subject Codes: N/A
BIO: 16035552

208. WHEELER, N.C., WAMPLE, R.L., PHARIS, R.P. Promotion of flowering Pinaceae by gibberellins 4. seedlings and sexually mature grafts of lodgepole pine Pinus-contorta.
Physiol. Plant, 1980, 50(4): 340-346
Subject Codes: 4.0
BIO: 71080477

Significant female flowering of 6-11 yr old seedlings and grafted ramets of sexually mature scions of lodgepole pine (P. contorta Dougl.) was promoted by both topical and spray applications of a GA4/7 mixture (1.6 to .approx. 5 mg per plant in total) during that period (June to Sept.) when sexual differentiation of lateral primordia took place. Girdling was used in most experiments to enhance the ga4/7 effect, as was the auxin, naphthaleneacetic acid (NAA). Average frequency of flowering branches on treated plants over all experiments ranged from 27-59% (control ranged from 0-36%) and average number of female strobili was increased from 2- to 6-fold by growth regulator treatment, relative to controls. Within an experiment, clonal or family frequency of flowering for treated plants ranged from 11-67% (controls were 0-28%) and number of female strobili was increased from 2- to 14-fold by growth regulator treatment, relative to controls. Movement of the flowering stimulus from the point of application was apparent in several experiments; the response in adjacent branches was correlated positively with increasing dosage of GA4/7. Significant male flowering occurred only in 1 experiment, girdling and GA4/7 treatment being promotive factors. The use of spray applications of GA4/7 + NAA is warranted to induce early and enhanced flowering in lodgepole pine seedlings and vegetative propagules for genetic improvement programs.

209. WHEELER, N.C., YING, C.C., MURPHY, J.C. Effect of accelerating growth on flowering in lodgepole pine Pinus-contorta-var-latifolia seedlings and grafts.
Can. J. For. Res., 1982, 12(3): 533-537
Subject Codes: 5.4
BIO: 75033474

Seedlings and grafts from lodgepole pine (P. contorta var. latifolia Dougl.) plus-tree selections in British Columbia (Canada) were established and maintained

in the greenhouse under 24-h photoperiod for 6 mo. Subsequently, seedlings were outplanted in the nursery and grafts in a breeding orchard at Red Rock Research Center. In the 5th year from seed (1980), the proportion of flowering trees and the average number of seed cones per flowering tree were roughly 6 times greater for accelerated growth seedlings (81%, 18 flowers/tree) than for controls (12%, 3.6 flowers/tree). Differences in pollen cone production were of similar magnitude. Flower enhancement in seedlings carried over into the next year. Grafted trees were considerably less productive than ed grafts compared with 1.6 strobili on 36% of untreated controls. These values decreased slightly in 1981. Pollen production was yet to be observed on grafted materials. While the superiority in height of accelerated seedlings relative to controls has steadily decreased since time of establishment, large differences in number of branches per tree and biomass remain. Root systems of accelerated seedlings generally were excessively pot-bound, resulting in considerable root grafting after outplanting. The possible causes of increased flower production in accelerated growth trees are briefly discussed. The production of both pollen and seed cones in numbers large engough to support a modest breeding scheme greatly increases the opportunity for rapid generation turnover in forest trees such as lodgepole pine and permits greater flexibility in planning a long- term tree improvement program.

## 2.9 SEED

210. BIROT, Y. Geographic variation in seed weight in Pinus contorta.
Silvae Genetica, 1978, 27(1): 32-40
23 ref.
Language: fr
Summary Languages: en, de
Subject Codes: 1.4, 5.4
CAB: 972528

Seed weight is tabulated for 140 provenances of P. contorta from throughout its natural range. The subspecies murrayana (from the Cascade Mts., Oregon and the Sierra Nevada, California) had significantly heavier seed than the subspecies contorta and latifolia. Seed weight within these 3 subspecies, and within the species as a whole, was negatively correlated with lat. and long., and, except for the coastal subspecies contorta, positively correlated with alt. The seed of the subspecies bolanderi (represented by only 1 provenance) was lighter than would have been predicted by its extreme southern latitude.

211. LOTAN, J.E., JENSEN, C.E. Estimating seed stored in serotinous cones of lodgepole pine.
US Forest Serv. Research Paper INT-83, 1970: 1-10
Subject Codes: 4.4
BIO: 52066265

212. SUTHERLAND, J.R. The pathogenic fungus Caloscypha-fulgens in stored conifer seeds in British Columbia, Canada and relation of its incidence to ground and squirrel cache collected cones.
Can. J. For. Res., 9(1), 1979: 129-132
Subject Codes: 2.8, 6.2, 6.6
BIO: 68063166

Stored seeds were assayed for the seed-borne fungus C. fulgens and the pathogen was found in 0, 25, 3, 0, 0, 0, 29, 16, 14, 0 and 0% of the seed lots of Abies amabilis, A. grandis, Pseudotsuga menziesii, Pinus ponderosa, P. monticola, P. contorta, Picea glauca, P. engelmanni, P. glauca X P. engelmannii hybrid, Tsuga mertensiana and T. heterophylla, respectively. Within infested seed lots, 0.4-22.4% of the seeds were infected. There was no relationship between incidence of infested seed lots and one year of cone collection or geographic origin. Squirrel-cache collected cones, especially of Picea spp., had the highest incidence, and slash-picked cones the lowest incidence, of C. fulgens infested seed lots. The percentage of diseased seeds, within infested seed lots, was unrelated to the origin of ground-picked cones.

## 2.10 WOOD

213. BENSON, R.E. Lodgepole pine products and utilization. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 602-613
7 ref.
Subject Codes: 8.1
CAB: 757727

The characteristics of Pinus contorta wood that influence its utilization are listed. At present, 300 million ft3/year are harvested in the US and Canada. Lodgepole pine accounts for 1% of U.S. softwood lumber output and 0.7% of wood consumed in the U.S. Most is manufactured into dimension lumber: demand for roundwood products (posts, poles and pulpwood) it limited. Development of future markets and demand for the wood are briefly discussed.

214. BRAZIER, J.D. A report on the effects of provenance on the timber properties of lodgepole pine. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 181-207
4 ref.
Subject Codes: 1.4
RCA: X1086

This paper summarizes wood properties of young (25 year old) lodgepole pine timber grown under plantation conditions in England. Discussion and tables provide information on provenance sources, anatomical and physical characteristics, compression strength and pulping properties.

215. COLE, D.M., JENSEN, C.E. Estimating phloem thickness in lodgepole pine stands using electrical resistance measurements.
Canadian Journal of Forest Research, 1980, 10(1): 102-106
15 ref.
Language: en
Summary Languages: fr
Subject Codes: 5.1
CAB: 1258884

Correlations among measurements of electrical resistance of cambial zone tissue, phloem thickness, and tree diam. reported earlier for other species were also found for lodgepole pine. Hence, a model was developed for estimating phloem thickness in lodgepole pine, an important factor in assessing stand susceptibility to mountain pine beetle (Dendroctonus ponderosae) epidemics. The predictive model and procedures for scaling estimates to specific time and location were tested with data from a lodgepole pine stand in Montana, USA, 160 km away from the sample trees used in fitting the model. Results for stand data grouped into 7.6 estimates were within plus or minus 4% of class means of phloem thickness for all diam. classes of the test stand. Model development and application procedures should be applicable to other species where estimates of phloem thickness and its distribution in stands is of interest. From authors' summary.

216. COLE, D.M. Estimation of phloem thickness in Lodgepole Pine.
USDA For. Serv. Research Paper, Intermountain For. and Range Exp. Stn., 1973, No. INT-148: 10 pp.
10 ref.
Subject Codes: 1.3, 6.1
CAB: 305171

Reports results of a study of 288 Pinus contorta var. latifolia trees (11-155 years old, 0.8-19.5" d.b.h., 8-103' tall) in unmanaged stands in W. Montana and SE Idaho. Phloem thickness was closely related to growth measurements that reflect past vigour, e.g. type. Equations are derived for predicting phloem thickness and the possibility is discussed of using phloem-thickness distributions

to assess the vulnerability of P. contorta stands to attack by Dendroctonus ponderosae.

217. COLE, D.M. Protecting and storing increment cores in plastic straws.
USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1977, No. INT-216: 3 pp.
1 ref.
Subject Codes: N/A
CAB: 939533

A method is described for sealing and joining plastic drinking-straws with cellulose acetate tape to prevent cores from drying and shrinking. The method was tested for 3- day and 21-day office storage of 0.5" segments of sapwood and 4" segments of heartwood of Pinus contorta and compared with results from air drying and soaking in water for 30 minutes. Maximum shrinkage of cores in sealed straws after 3 days was 0.008" and this method gave better results than soaking. Shrinkage was significantly greater after 21 days and was significantly greater for sapwood than for heartwood. Fungal growth was found on cores stores for 21 days. Freezer storage of sealed straws is therefore suggested for periods of more than 3 days.

218. DIAZ-VAZ OLMEDO, J.A., KNIGGE, W., ECHOLS, R. Comparisons between variations in wood density measured by X-rays and changes in wood anatomy within the annual ring.
Bosque, 1975, 1(1): 33-42
41 ref.
Language: es
Summary Languages: de, en
Subject Codes: 1.3
CAB: 783214

Values of density within an annual ring and the dimensional variation of cells are compared in wood of Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta). The results show a great similarity between the two measurements when compared in averaged sections every 0.24 mm in the radial direction. Measurements of cell dimensions in the annual ring and determinations of packing density are presented. The influence of cell-wall thickening and cell diameter (thickening and flattening effect) on the change from early to late wood is also analyzed and discussed.

219. DIAZ-VAZ, J.E., ECHOLS, R., KNIGGE, W. Comparative study of the variations of tracheid dimensions, and of basic density as determined by X-rays, within the annual rings (of Pseudotsuga menziesii and Pinus contorta).
Forstwissenschaftliches Centralblatt, 1975, 94(4/5): 161-175
43 ref.
Language: de
Summary Languages: en
Subject Codes: 1.3
CAB: 536661

Increment cores were studied by X-ray densitometric and micrometric techniques. Cell-wall thickness and tracheid diameters were measured radially and tangentially. Density as determined by the X-ray technique was significantly correlated with the amount of cell-wall substance present. Differences between the curves for optical and X-ray measurements were found only in a small zone of early wood. Cell-wall density was computed as being 1.01 g/cm3 for Douglas-fir and 1.07 g/cm3 for lodgepole pine at a moisture content of 12%; it did not vary significantly within annual rings. In general, radial walls tended to be slightly thicker than tangential walls in Douglas-fir, and slightly thinner in lodgepole pine. Radial diameters of tracheids tended to decrease from early to late wood in both species. The authors discuss the effect on density variation within the annual ring of changes in cell-wall thickness on the one hand and cell diameter on the other.

220. HAKKILA, P., PANHELAINEN, A. On the wood properties of Pinus-contorta in Finland.
Metsantutkumuslaitoksen Julk., 1970, 73(1): 5-43
Subject Codes: 1.3
BIO: 52107567

221. HATTON, J.V., MCGOWAN, W.M. Strength properties of flooded timber and its utilization for kraft pulp.
Info. Rep., Western Forest Products Laboratory, Canada, 1975, No. VP-X-150: iii + 26 pp.
16 ref.
Language: en
Summary Languages: fr
Subject Codes: 8.1
CAB: 585276

A study of the utilization of a large volume of timber that has been submerged for long periods after the creation of a man-made reservoir. An evaluation of the strength properties of samples of submerged Pinus contorta var. latifolia and Picea glauca var. albertiana showed a considerable reduction in modulus of elasticity in bending and in compression strength, due to the plasticizing effect of submersion. Experiments on kraft pulping showed that chip quality and pulp yield and quality were satisfactory. The material is recommended for production of unbleached or bleached kraft pulps.

222. HEGER, L. Longitudinal variation of specific gravity in stems of black spruce, balsam fir, and lodgepole pine.
Canadian Journal of Forest Research, 1974, 4(3): 321-326
7 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 409633

Ten disks per tree, cut at roughly equidistant intervals throughout the whole length of the stem, were taken from 50 Picea mariana, 50 Abies balsamea and 36 Pinus contorta var. latifolia trees representative of various geographic areas and sizes. The relation between disk sp. gr. (dependent variable) and relative disk height in these trees was investigated. The simplest polynomial adequately describing the relation was a parabola whose minimum was at mid-stem in the spruce and fir, and at 70% of total height in the pine. The linear term was significant only in the pine, and could be detected with 95% confidence if at least 14 trees were sampled. The quadratic term could be detected with 95% confidence if at least 48 spruce, 8 fir or 38 pine trees were sampled. It is concluded that conflicting evidence in studies of longitudinal variation of sp.gr. in Picea spp. may be attributable to use of a sample containing too few trees. In the study reported, deviations of the sample averages from the fitted values showed a similar pattern for each species; this suggests that the action of factors governing wood structure in stems of conifers depends more on the relative height in the stem than on species, geographic area or absolute size.

223. HENDERSON, J., PETTY, J.A. A comparison of wood properties of coastal and interior provenances of lodgepole pine Pinus contorta Dougl. ex loud.
Forestry, 1972, 45(1): 49-57
18 ref.
Subject Codes: N/A
CAB: 055292

There were significant differences between American coastal provenance material and Canadian inland provenance material grown at Millbuie, UK, in ring width, percentage of early wood, early-wood density, tracheid length and width, nominal density and late- wood density. In the coastal material, nominal density was about 20% higher than in the inland material and the incidence of compression wood was much higher, but the tracheids were about 20% shorter. There was a low positive correlation between nominal density and ring width.

224. LIEU, P.J., KELSEY, R.G., SHAFIZADEH, F. Some chemical characteristics of green and dead lodgepole pine and western white pine.
U.S. For. Serv. Research Note, Int. 0(256), 1979: 1-8
Subject Codes: N/A
BIO: 18003646

225. MAEGLIN, R.R., WAHLGREN, H.E. Western wood density survey report number 2.
US For. Serv. Research Paper FPL-183, 1972: 1-24

Subject Codes: N/A
BIO: 73034723

226. MARKSTROM, D.C., HANN, R.A. Seasonal variation in wood permeability and stem moisture content of 3 Rocky Mountain softwoods.
US For. Serv. Research Note, RM-212, 1972: 1-7
Subject Codes: N/A
BIO: 72056660

227. MURARO, S.J. Offal timber of lodgepole pine trees.
Can. Dep. Forest and Rural Development, Forest Br. Dep. Publ. (1154153F), 19 1-11
Subject Codes: 8.1
BIO: 51051823

228. SANDBERG, K.R., HERRICK, F.W., SELDERS, A.A. Paraquat treatment of northwest conifers for lightwood induction.
Wood Science, 1977, 10(1): 28-30
6 ref.
Subject Codes: 7.6
CAB: 806390

Trees 30-40 years old of western hemlock (Tsuga heterophylla), Douglas-fir (Pseudotsuga menziesii), Sitka spruce (Picea sitchensis), lodgepole pine (Pinus contorta) and western redcedar (Thuja plicata) growing in Washington were sprayed with 8% paraquat sol. on exposed cambial tissue 30-45 cm above ground in Aug. 1974 and were harvested in March 1975. Discs were removed from each stem above and below the wound and were examined visually, photographed and analyzed for resin and fatty acids. Treated lodgepole pine showed increased volatile oil and free acid content at the wound, but no visible sign of lightwood formation was detectable 1.2 m above it. The response of Douglas-fir was anomalous, because one treated tree showed increased volatile oil content while a second did not. Treated western hemlock, western redcedar and Sitka spruce trees showed death of cambial tissue at the wound area, but there was no significant lightwood formation in these species.

229. SHRIMPTON, D.M. Extractives associated with wound response of lodgepole pine attacked by the mountain pine beetle and associated microorganisms.
Canadian Journal of Botany, 1973, 51(3): 527-534
33 ref.
Language: en
Summary Languages: fr
Subject Codes: 6.2
CAB: 122304

Changes in extractive content that occur in the sapwood of Pinus contorta var. latifolia in response to attack by Dendroctonus ponderosae and associated micro-organisms were studied. The most striking change was a large increase in total terpene content to an amount well above that normally observed in sapwood or heartwood. Free acids, phenolic compounds and neutral components increased to a final concentration about the same as that in the heartwood, but at a much slower rate than terpenes. Free sugar content decreased apart from beta-phellandrene, no usually high or low values for the content of any one compound were observed in the wound-response tissues, and all the components found were normal constituents of heartwood.

230.. TAYLOR, F.W., WANG, E.I.C., MICKO, M.M. 1982. Differences in the wood of lodgepole pine in Alberta. Wood and Fiber 14(4):296-309.

Significant tree-to-tree differences in both relative density (RD) and tracheid length were found in lodgepole pine trees growing in the mountains of western Alberta. No geographic variations of the properties were observed, but within geographic growth zones, trees growing at lower elevations had longer tracheids. Within the stem, RD decreased as ht. above ground increased. The relationship of age (rings from pith) and RD was different at different sampling heights within stems. At all heights tracheid length increased with

age. From authors' summary.

231. ZALASKY, H. Anatomical modifications in xylem of lodgepole pine container seedlings induced by TOK-E-25 (nitrofen).
Bi-monthly Research Notes, 1978, 34(3): 13-15
4 ref., 2 pl.
Subject Codes: 1.3, 7.3
CAB: 1273088

The effects are described of weekly applications of nitrofen for 3 months on the 1st and 2nd-yr wood of seedlings maintained outside for their first growing season. Fibril modifications observed in the tracheids were similar to those caused by frost. Nitrofen also delayed maturation of daughter tracheids, reduced seedling growth, and caused the development of abnormal buds.

## 2.11 PHYSIOLOGY

232. BALDWIN, V.C., BARNEY, C.W. Leaf water potential in planted ponderosa and lodgepole pines.
For. Sci., 1976, 22(3): 344-350
Subject Codes: N/A
BIO: 63026244

Leaf water potential of 854 planted and naturally established ponderosa (Pinus ponderosa) and lodgepole pine (P. contorta) seedlings from sample plots on the Front Range of northern Colorado (USA), was measured in the field using a pressure chamber. Air temperature, vapor pressure deficit, soil moisture and aspect were highly correlated with leaf water potential. Significant differences in water potential between plantings were related to species, seed source, year of planting and shoot/root ratio. Ponderosa pine usually required 2 growing seasons after planting in prevalent subhumid conditions before new root growth was effective in raising low leaf water potential to the level of natural seedlings.

233. BASSMAN, J.H. Ecophysiological basis for growth repression in lodgepole pine. E.P. 893.01. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 42
Subject Codes: N/A
RCA: X1055

234. BENECKE, U., HAVRANEK, W., MCCRACKEN, I. Comparative study of water use by tree species in a mountain environment. IN: Proceedings of Soil and Plant Water Symposium, Palmerston North, New Zealand, 25-27 May, 1976.
Info. Series, New Zealand Dept. of Science and Industrial Research, 1977, No. 126: 191-199
4 ref.
Subject Codes: 8.8.3
CAB: 1200331

A mobile laboratory is being used to monitor transpiration and $CO_2$ gas exchange of planted Pinus mugo, P. contorta and Larix decidua, and naturally regenerated nothofagus bolandri spp. cliffortioides in the Craigieburn Range, Canterbury, at altitudes 900-1300 m a.s.l. The daily course of gas exchange with respect to the main climatic parameters is presented for selected days during the 1975-76 growing season. Comparisons are made between species with special reference to the influence of vapour pressure deficit (v.p.d.) on transpiration during weather when large v.p.d. is reached. Indications are that per unit foliage transpiration rates increase in the order P. mugo, P. contorta, N. bolandri, L. decidua. Optimum days for maximum primary productivity at the expense of only moderate water loss occur in fine but cool weather (ca. 12-15 deg. C) with v.p.d. remaining below 8 mb when soils are close to field capacity. An attempt is made to extrapolate branch transpiration data to account for tree and stand water losses at various altitudes.

235. BOGGIE, R. Effect of water table height on root development of Pinus-contorta on deep peat in Scotland.
Oikos, 1972, 23(3): 304-312
Subject Codes: 2.3
BIO: 56025572

236. BRIX, H. Effects of plant water stress on photosynthesis and survival of 4 conifers.
Can. J. For. Res., 1979, 9(2): 160-165
Subject Codes: 2.1
BIO: 69029669

Seedlings of 4 coniferous species, Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), western hemlock (Tsuga heterophylla (Raf.) Sarg.), white spruce (Picea glauca (Moench) Voss) and lodgepole pine (Pinus contorta Dougl.), were grown for 4 mo. from germination and were then exposed to soil drying. Rates of photosynthesis were measured for all species and rates of dark respiration and transpiration were measured for Douglas-fir and hemlock. In a study of survival, seedlings were exposed to various durations of soil drying and the plant water potential was determined before the plants were rewatered; seedling survival was subsequently recorded. Rates of photosynthesis declined for Douglas-fir, hemlock, spruce and pine when the plant water potential decreased from - 10.0 -10.7, -12.4 and -6.6 bars (1 bar = 100 kPa), respectively, and became zero with potentials of -53.9, -39.7, -28.6 and -22.4 bars. When grown together in the same pot and exposed to soil drought, hemlock had a consistently lower potential than Douglas-fir and spruce had a lower potential than pine. Hemlock could survive potentials of -40 to -60 bars, whereas seedlings of the other species survived potentials to -110 bars. (This research has application for seedling survival in forestry plantations during summer drought.)

237. COCHRAN, P.H. Tolerance of lodgepole pine and ponderosa pine seeds and seedlings to high water tables.
Northwest Sci., 1972, 46(4): 322-331
Subject Codes: N/A
BIO: 57066073

238. COUTTS, M.P., ARMSTRONG, W. Role of oxygen transport in the tolerance of trees to waterlogging. IN: Proceedings of a Conference on Physiological Genetics of Forest Tree Yield, Gorebridge, Scotland, July 13-21, 1975. XVII + 567 pp.
Academic Press, London, England, 1976: 361-385
Subject Codes: N/A
BIO: 15001312

239. COWLING, J.E., KEDROWSKI, R.A. Winter water relations of native and introduced evergreens in interior Alaska.
Can. J. Bot., 1980, 58(1): 94-99
Language: en
Summary Languages: fr
Subject Codes: 6.4
LISC: 465649

In view of wintertime browning of needles of pines introduced in Alaska, winter desiccation damage was suspected. However, examination of field xylem water potentials and relative water contents indicated little water stress in pine needles but severe stress in sunny native spruce needles and slightly less stress in shaded needles. Spruce (Picea glauca) were typical of drought tolerant plants and pines were drought avoiding. Needles of all species photosynthesized at temperatures from 0 to 10 deg. C with rates in spruce being 10 times those in yellow pine (Pinus banksiana) and 3 times those in lodgepole pine (Pinus contorta). While spruce needles had significantly more carbohydrate reserves at the end of the winter than did pine needles, the latter were apparently not severely carbohydrate depleted.

240. DYKSTRA, G.F. Drought resistance of lodgepole pine seedlings in relation to

provenance and free water potential.
Research Notes, British Columbia Forest Service, 1974, 62: 7 pp.
Subject Codes: 1.4, 6.4
CAB: 403955

Two-year-old strains of Pinus contorta of diverse origin exhibited differences in shoot height, root volume, fresh weight and survival scores in relation to provenance and free water potentials in greenhouse experiments, indicating differences in drought resistance between them.

241. EDWARDS, W.R.N., JARVIS, P.G. A new method of measuring water potential in tree stems by water injection.
Plant, Cell and Environment, 1981, 4(5): 463-465
2 ref.
Subject Codes: N/A
CAB: 1569935

The xylem water potential is calculated from the flow rate of water injected into the xylem at 2 or more known pressures. Data are presented for Pinus contorta 4 m high in calm or windy autumn weather. The method works only on actively transpiring trees.

242. ETTER, H.M. Assessment of drought resistance in conifer seedlings grown under various nitrogen regimes. IN: Abstracts of the Papers Presented at the XI International Botanical Congress and the International Wood Chemistry Symp. 260 pp.
XI International Botanical Congress, Seattle, WA, USA, 1969: 56
Subject Codes: N/A
BIO: 69081351

243. FAHEY, T.D. The effect of night frost on the transpiration of pinus-contorta-ssp-latifolia.
Oecol. Plant, 1979, 14(4): 483-490
Subject Codes: 6.4
BIO: 69070554

A series of several warm days and nights was required to stimulate stomatal opening in lodgepole pine in the spring after the cold Wyoming (USA) winter when very little transpiration occurred. Overnight frost reduced leaf conductance the following day, and midday leaf conductance (CL) was highly correlated with the mean temperature of sub-freezing nights. Although base xylem pressure potential was influenced by overnight freezing, it was not correlated with CL, suggesting that frost may directly affect stomatal physiology. Following non-freezing nights during the spring (when soil temperature is near 0 degree C), transpiration appeared to be limited by water uptake at the roots, with internal water stress developing in the trees during the day.

244. FETCHER, N. Patterns of leaf resistance of lodgepole pine transpiration in Wyoming, USA.
Ecology, 1976, 57(2): 339-345
Subject Codes: N/A
BIO: 62039812

Leaf resistance (rL) of lodgepole pine (Pinus contorta ssp. latifolia) was measured with an aspiration porometer at 3 sites in the Medicine Bow Mountains, Wyoming (USA). In the early part of the growing season all the sites had low leaf resistances (3-5 s/cm) and few significant changes in rL during the day. Towards the end of the growing season, in Aug., significant increases in midday leaf resistance occurred at all sites. The greatest increase (to 57 s/cm) was found on the driest site. Smaller increases (to 10-14 s/cm) were measured at a dry-mesic site and a mesic site. Stomatal control of transpiration was probably more important toward the end of the growing season and that the degree of control varied with the soil water regime of the site. The response of rL to soil H20 status appeared to be nonlinear. When base pressure potential readings were above an upper threshold (.apprxeq. -9 bars) rL did not increase during the day. Below a lower theshold (.apprxeq. -17 bars) rL increased significantly. Between the 2 thresholds, changes in rL under high light conditions were explained more readily by the interaction between vapor pressure deficit and soil H20 status than by

either factor alone.

245. FISHER, J.T., REID, C.P.P. Transpiration of Arceuthobium-americanum and Pinus-contorta under increasing levels of water stress.
Proc. Am. Phytopathol. Soc., 2, 1975: 29-30
Subject Codes: 8.8.3
BIO: 76068327

246. HOCKING, D., MITCHELL, D.L. The influences of comminution and compression of substratum peat on growth and drought tolerance of lodgepole pine container seedlings.
Can. J. For. Res., 3(3), 1973: 342-345
Language: en
Summary Languages: fr
Subject Codes: 7.3
BIO: 57054630

247. KAUFMANN, M.R. Evaluation of season temperature and water stress effects on stomata using a leaf conductance model.
Plant Physiol. (Bethesda), 1982, 69(5): 1023-1026
Subject Codes: N/A
BIO: 75017290

A model was developed earlier describing conductance for 3 conifers (Picea engelmannii Parry ex Engelm., Abies lasiocarpa (Hook.) Nutt. and Pinus contorta var. latifolia Engelm.) and 1 hardwood (Populus tremuloides Michx.) using only 2 terms, photosynthetic photo flux density (PPFD) and absolute humidity difference from leaf to air (DAH). Using residual analysis techniques (actual minus estimated conductance), it was determined that no seasonal or temperature effects existed that were not taken into account with PPFD and DAH. Conductance was reduced on days following cold nights (below 4 deg. C) or, in aspen, when xylem pressure potential was less than -20 bars. A mathematical model is given to take these terms into account.

248. KAUFMANN, M.R. Leaf conductance as a function of photosynthetic photon flux density and absolute humidity difference from leaf to air.
Plant Physiol. (Bethesda), 69(5), 1982: 1018-1022
Subject Codes: N/A
BIO: 75017289

For an entire season of stomatal activity, leaf or needle conductance was observed on 4 spp., each in a different genus: Engelmann spruce (Picea engelmannii Parry ex Engelm.), subalpine fir (Abies lasiocarpa (Hook.) Nutt.), lodgepole pine (Pinus contorta var. latifolia Engelm.) and aspen (Populus tremuloides Michx.). Conductance in the natural environment was described for all species by photosynthetic photo flux density (PPFD) and absolute humidity difference from leaf to air (DAH). The only data not fitting this relationship were conifer data collected after freezing nights or aspen data collected during a short period in Aug. when water stress occurred. In both cases, leaf conductance was reduced. Apparently, PPFD and DAH are primary factors controlling stomatal function for plants growing in their native range; secondary factors, such as temperature and water stress, affect conductance intermittently, except when plants are growing outside their normal environmental conditions.

249. KAUFMANN, M.R., TROENDLE, C.A. The relationship of leaf area and foliage biomass to sapwood conducting area in 4 subalpine forest tree species.
For. Sci. 1981, 27(3): 477-482
Subject Codes: 2.2, 2.7, 5.6
BIO: 73046237

Leaf dry weight and area were strongly correlated with sapwood area measured at 1.37 m, but leaf area per unit sapwood area varied widely among species: 1.88 m2 .cntdot. cm-2 for subalpine fir, 0.72 for Engelmann spruce, 0.44 for lodgepole pine and 0.19 for aspen (Picea engelmannii, Abies lasiocarpa, Pinus contorta and Populus tremuloides). The leaf area:sapwood area relationship was nearly constant for different portions of the crown, although the relationship was erratic in

subalpine fir. The upper portion of a larger tree has the same leaf area:sapwood area ratio as the entire crown of a smaller tree. This supports the hypothesis that a physiological balance exists between conducting tissue and the water requirements of the shoot.

250. KNAPP, A.K., SMITH, W.K. Water relations and succession in subalpine conifers in southeastern Wyoming.
Bot. Gaz., 1981, 142(4): 502-511
Subject Codes: 3.4
LISC: 643208

The water relations of three successional conifers, Pinus contorta var. latifolia Engelm., Picea engelmannii Parry, and Abies lasiocarpa (Hook.) Nutt., were monitored at early successional (open) and late successional (understory) sites through the summer of 1980 in southeastern Wyoming. Maximum leaf conductance to water vapor diffusion (gwv) at the open site was greatest in A. lasiocarpa (6.1 mm s-1), intermediate in P. contorta (3.9 mm s-1), and least in P. engelmannii (1.5 mm s-1). Although values of maximum gwv were lower in all three conifers at the understory site than at the open site, the decrease was much greater for P. contorta (64%) versus A. lasiocarpa (39%) and P. engelmannii (13%). Differences in water relations among the three conifers may contribute to the observed early successional status of P. contorta compared with the late successional conifers (P. engelmannii and A. lasiocarpa) in the subalpine zone of the Rocky Mountains.

251. KNIGHT, D.H., FAHEY, T.J., et al. Transpiration from 100-year-old lodgepole pine forests estimated with whole-tree potometers.
Ecology, 1981, 62(3): 717-726
Subject Codes: 5.6
LISC: 635336

Whole-tree potometers were used to estimate transpiration from two contrasting stands of 100-year-old lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) forest growing on the same site in southeastern Wyoming. Although one stand had nearly identical leaf area indices (7.3 and 7.1) and clear-day transpiration rates (3.3 and 3.4 mm/d). Individual tree basal area and maximum observed 24-h uptake were highly correlated, with the largest trees 20-26 cm dbh) transpiring 40-44 L on clear days in early summer. Maximum observed hourly uptake for the larger trees was 2.5-3.5 L, with total nighttime uptake being about 12% of 24-h uptake. On overcast days potometer-uptake was reduced by 20-44%; during rainy periods uptake was reduced to nearly zero. The results are compared to data obtained with different methods by other investigators, with the conclusion that whole-tree potometers can be a useful tool for studies on tree water relations and for estimating short-term forest transpiration when leaf water potential is not limiting leaf conductance.

252. KUPFERBERG, S. Cuticular resistance of conifers in relation to the tree line.
J. Biol. (Bronx, N.Y.), 1980, 50(2): 7-10
Subject Codes: N/A
BIO: 21047125

253. LEISER, A.T., HARRIS, R.W., PAUL, J.L. Evaluation, selection and propagation of landscape plants for survival characteristics.
Project CA-D-EHT-3335-H, Univ. of California, Davis, CAL, 13 Sep 74 to 30 Sep 80
Subject Codes: 1.2, 7.4.4
CRIS: 0066437

Objectives: Develop efficient methods of screening plant species for their ability to withstand and perform well under stress conditions. Approach: Investigate the relationship between certain physiological and morphological characteristics and the ability of plants to withstand specific stress situations. The relationships between salinity tolerance and cell sap osmotic concentration and drought tolerance and photosynthetic dark reaction pathways will be investigated. Verification of the validity of screening techniques developed will be accomplished by field testing. Progress: A five year study investigated the relationship between highway operation and plant damage in the Tahoe Basin and adjacent highways. These studies included field surveys, greenhouse studies, soil salt application trials, foliar salt application trials, an Armillaria root rot inoculatin study, a seasonal fluctuation of salt study, the effect of temperature on salt uptake and a bark absorption of salt study. Highway deicing salt is a

cause of damage on conifers, usually limited to 30 feet from the pavement edge. Drainage patterns and salt carried by aerosols may extend damage farther from the pavement. Beetles were an important cause of damage along highway corridors of the study area. Depth of fill and armillaria root rot had little apparent effect. Of the four principal conifers in the study area, Jeffrey pine and lodgepole pine appeared the most tolerant of salt and incense cedar was the most susceptible. The true firs were intermediate in sensitivity. Symptoms and estimated critical threshold levels of leaf Na and Cl are given. The soils of the study area appear to leach well and there was no evidence of salt build-up during the course of the study. Root uptake of salt is low when air temperatures are low. There did not appear to be uptake of salt through the bark of the trees. The findings of this study are compared to those of Scharpf and Srago for the Tahoe Basin.

254. LOPUSHINSKY, W. Stomatal closure in conifer seedlings in response to leaf moisture stress.
Bot. Gaz., 1969, 130(4): 258-263
Subject Codes: N/A
BIO: 51063008

255. LOPUSHINSKY, W., KLOCK, G.O. Transpiration of conifer seedlings in relation to soil water potential.
For. Sci., 1974, 20(2): 181-186
Subject Codes: 2.3
CAB: 59001981

256. LOTAN, J.E., JOYE, N.M. Jr. Some variation of terpenes in Montana lodgepole pine.
US Forest Serv. Research Note INT-120, 1970: 1-4
Subject Codes: N/A
BIO: 71022745

257. MARK, W.R., REID, C.P.P. Lodgepole pine dwarf mistletoe xylem water potentials.
For. Sci., 17(4), 1971: 470-471
Subject Codes: 6.2
BIO: 53062833

258. MILLER, D.R., BERGEN, J.D., GILBERT, M.J. Vertical and horizontal temperature and vapor pressure profiles in a lodgepole pine stand.
IN: Proceedings 14th Conference on Forest and Agr. Meteorol., Am., Meteorol. Soc., 1979.
Subject Codes: N/A
RCA: X1200

259. PERRY, D.A., LOTAN, J.E., HINZ, P., HAMILTON, M.A. Variation in lodgepole pine family response to stress induced by polyethylene glycol 6000.
For. Sci., 1978, 24(4): 523-526
Subject Codes: 5.4
BIO: 68053488

Lodgepole pine (Pinus contorta) seedlings from 19 wind-pollinated families representing 6 populations were grown under varying levels of osmotic stress induced by polyethylene glycol 6000. Measurements of dry weight and vigor responses showed that families varied significantly in stress resistance, but populations did not. Purposeful alteration of the forest genetic system should consider stress resistance, as well as growth characteristics. Individual tree selection for resistance to the type of stress imposed here may be more efficient than the provenance approach.

260. REYNOLDS, J.F., KNIGHT, D.K. Hydrologic characteristics of spruce, fir and lodgepole pine forest litter in Wyoming.
J. Colo-Wyo. Acad. Sci., 1972, 7(2-3): 106
Subject Codes: N/A
BIO: 73004888

261. RITCHIE, G.A., RODEN, J.R., KLEYN, N. 1985. Physiological quality of lodgepole pine and interior spruce seedlings: effects of lift date and duration of freezer storage. Canadian Journal Forest Research. 15(4):636-645.

Owing to frozen ground, nurseries in interior Oregon, Washington, and British Columbia are often unable to lift bare-root seedlings during midwinter when they are in peak physiological condition. Therefore, seedlings are normally lifted in the autumn and planted either immediately or after overwinter storage, or lifted in the spring and planted either immediately or after brief storage. This study was conducted to ascertain which of these strategies produced planting stock of the highest physiological quality. The species evaluated were lodgepole pine and interior spruce (Picea glauca/engelmannii complex). Seedlings were grown in a Weyerhaeuser Canada nursery in British Columbia and lifted on 9 dates from early Oct. 1982 to late March 1983. Seedling quality was evaluated at each lift date and following 2 and 6 months storage at -1 degC. Evaluations consisted of measurements of dormancy release index, root growth potential (RGP), stress resistance (SR), and frost hardiness (FH). The main effects of lift date and storage duration were generally highly significant on all seedling-quality attributes. Lift date-storage duration interactions were also highly significant in most cases. Dormancy weakened throughout winter in the nursery, with accumulated chilling. Storage slowed the release of dormancy for most lift dates. RGP was very high in autumn-lifted seedlings, but declined rapidly after storage. RGP again increased in late winter, but was not appreciably affected by storage except for March-lifted seedlings. SR was relatively high in autumn-lifted seedlings and very low in spring-lifted seedlings. SR was also reduced by storage, especially after 6 months. However, SR did not fall as rapidly in stored seedlings as it did in seedlings left in the nursery bed. FH was -30 degC in early October, during midwinter FH was beyond the limit of measurement (-40 degC). Seedlings of both species appeared to deharden in storage, but at a relatively slow rate. It is concluded that the best operational strategy is autumn lifting, beginning November 1, with overwinter storage at -1 degC. Spring-lifted seedlings tended to exhibit low RGP, low SR, low FH, and poor storability.

262. RUDLOFF, E. VON, LAPP, M.S., MCMINN, R.G. 1985. Chemosystematic studies in the genus Pinus. V. variation in the leaf oil terpene composition of young and old lodgepole pine trees from different moisture regimes near Prince George, British Columbia. Canadian Journal Forest Research. 15(5):801-208.

Leaf oil terpene composition was investigated in samples collected from lodgepole pine stands from contrasting moisture regimes (400-1200 mm annual precipitation) within upland and bog sites. In addition to the terpene patterns recorded previously, a new one with relatively high percentages (5-28%) of the terpinene group was found. This pattern was encountered mainly in old trees with very low yields (0.1%) of volatile oil, especially in trees from shaded stands. The absence of resin canals in the leaves of such trees may be the reason for the low yields, but the reason for the link with relatively high terpinene group percentages is obscure. Young trees growing in the vicinity of such stands had mainly normal patterns. No differences between upland and bog sites or dry and wet sites were found in young trees indicating that old trees from bogs or wet sites east of Prince George provided progeny with the normal terpene patterns, even though many of the old trees had the new terpene pattern. Samples from two 12- to 13-year-old provenance trials originating from west and east of Prince George had terpene patterns similar to those of the young trees from the natural stands.

263. RUNNING, S.W. Environmental and physiological control of water flux through Pinus contorta.
Can. J. For. res., 1980, 10(1): 82-91
31 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.1, 8.8.3
LISC: 493262

Measurements of leaf conductance, leaf water potential, temperature, humidity, and radiation collected on a stand of P. contorta throughout a growing season at the Fraser Experimental Forest in central Colorado, USA are reported. The daily range of leaf conductances decreased 10-fold from June to August. A high correlation (R2=0.75) was found between predawn leaf water potential and morning maximum leaf conductance. Low atmospheric humidity significantly decreased midday leaf conductance. A comparison with humidity responses published for other conifers

showed good agreement with this study. Seasonal change in total soil-plant resistance to water flux was nonlinearly correlated (R2=0.99) with change in predawn leaf water potential, an indirect measure of soil water potential.

264. RUNNING, S.W. Relating plant capacitance to the water relations of Pinus-contorta.
For. Ecol. Manage., 1980, 2(4): 237-252
Subject Codes: N/A
BIO: 70067632

Internal water storage of P. contorta Dougl. ex. Loud. (lodgepole pine) was estimated by both calculation and measurement. Readily available water from internal storage was calculated to be capable of providing 0.6 h of maximum transpiration. This estimate was substantiated by direct measurement. Needle water content contributed only 4% of total storage, but had an important role in stomatal response through the control of leaf conductance by leaf water potential. Leaf water potential was highly correlated with needle water content when measurements were taken under low transpiration conditions which minimized the flow-related component of water potential. When trees were cut and allowed to dry upright, the needles retained water and a stable leaf water potential for up to 33 days as the stem sapwood was depleted. Sapwood water content of intact trees remained fairly constant at 60-70% of saturation throughout the summer.

265. RUNNING, S.W. Field estimates of root and xylem resistances in Pinus-contorta using root excision.
J. Exp. Bot., 1980, 31(121): 555-570
Subject Codes: 2.3
BIO: 70060684

A root excision technique was used to estimate that proportion of total resistance to water flux residing in the soil, the root and the xylem of lodgepole pine (P. contorta Dougl. ex. Loud.) trees in the field. Root excision at mid-day always resulted in rapid recovery of leaf water potential when water was supplied to the cut stem, suggesting a high soil-root resistance. Transpiration was unaffected if leaf water potential before cutting was not limiting leaf conductance. By mid-June water uptake by the excised stem always exceeded calculated crown transpiration indicating recharge of internal sapwood storage. Predawn leaf water potential before root excision was highly correlated with total soil-plant resistance (r2 = 0.89) and calculated root water uptake (r2 = 0.92).

266. RUNNING, S.W., REID, C.P. Soil temperature influences on root resistance of Pinus-contorta seedlings.
Plant Physiol. (Bethesda), 1980, 65(4): 635-640
Subject Codes: 2.3
BIO: 70040063

The influence of low temperature in the root zone on water uptake in lodgepole pine (P. contorta Dougl. ex Loud.) was studied under laboratory conditions. To remove soil hydraulic influence, 2-yr-old seedlings were transferred to solution cultures and maintained in temperature controlled water baths. Short-term measurements of leaf conductance, leaf water potential and tritiated water movement were taken at root temperatures from 22 degree down to 0 degree C. Root resistance was calculated to be 67% of total plant resistance at 7 deg. C and 93% at 0 deg. C. In addition, an Arrhenius break was found in a plant resistance vs.temperature plot, suggesting a significant change with temperature in the membrane pathway in the root water uptake system.

267. SALAMON, M. Resistance moisture meter correction factors for western softwood species.
For. Prod. J., 1972, 22(12): 46-47
Subject Codes: N/A
BIO: 73033348

268. SCOTT, D. Comparison between lodgepole pine and mountain beech in establishment and carbon dioxide exchange.
New Zealand J. Bot., 1970, 8(3): 357-360
Subject Codes: N/A

BIO: 52054569

269. SHRIMPTON, D.M., THOMPSON, A.J. 1985. Relationship between phloem thickness and lodgepole pine growth characteristics. Canadian Journal Forest Research. 15(5):1004-1008.

Depth of the phloem (inner bark) layers in lodgepole pine (Pinus contorta var. latifolia) is a factor in the development of outbreaks of the mountain pine beetle (Dendroctonus ponderosae). Five lodgepole pine stands in the interior of British Columbia spanning the ages affected by this beetle (47-147 yr) were studied. Relationships were determined between thickness of the phloem layer and radial and B.A. increments over various periods of time, as well as D.B.H. The thickness of the phloem layer declined over the age spanned in this study. The best predictor of phloem thickness was the B.A. increment in the 6-10 yr before sampling. D.B.H. was a poor predictor of phloem thickness.

270. SMITH, W.K. Importance of aerodynamic resistance to water use efficiency in 3 conifers under field conditions.
Plant Physiol. (Bethesda), 1980, 65(1): 132-135
Subject Codes: N/A
BIO: 69070570

The quantitative importance of aerodynamic resistance to H20 vapor and C02 exchange was determined for shoots from saplings of 3 conifers (Abies lasiocarpa (Hook) Nutt., Pinus contorta Dougl., Juniperus communis L.) under natural conditions in the field. A combination of relatively low stomatal resistances ( 300 s/cm) and low wind speeds ( 30 cm/s led to substantial contributions of the aerodynamic resistance GRAPHIC to water use efficiency (WUE = Photosynthesis/transpiration) for all 3 spp. For A. lasiocarpa, transpiration was calculated to be 44% less and photosynthesis 17% less due to the presence of GRAPHIC which led to a predicted increase in WUE of 57% compared to the calculated WUE when GRAPHIC was assumed negligible. Similar increases in WUE were computed for P. contorta (48%) with somewhat smaller values for J. communis (34%). These results are discussed in terms of the estimated importance of GRAPHIC on water and photosynethesic relations of plants that had relatively low stomatal resistances and grow in microhabits with low winds.

271. SPOMER, G.G., STOSZEK, K.J. Comparisons of water potentials in bole and needle tissues of lodgepole pine.
Can. J. For. Res., 1978, 8(4): 439-441
Subject Codes: 2.2, 2.7
BIO: 68005417

Osmotic potentials of combined phloem and cambial tissues from stem plugs were compared with those of needles taken concurrently from the same Pinus contorta Dougl. ex Loud var. latifolia Engelm. Overall, stem tissue potentials were about twice as high (less negative) as those of needles, and no correlation was found to exist between values from these 2 tissues. On the other hand, no significant differences existed between potentials in tissues from different heights or between north and south exposures on the same bole.

272. SWANSON, R.H. Sampling for direct transpiration estimates.
J. Hydrol., 1970, 9(2): 72-77
Subject Codes: N/A
LISC: 580171

Heat-pulse velocities are directly indicative of transpiration rate. The transpiration of individual trees or stands can be compared provided the heat-pulse velocity values are representative of and from comparable water-conducting xylem. The results of a pre- sample to determine the statistical sampling intensities necessary to obtain comparable heat-pulse velocity data from lodgepole pine showed that 10 trees would constitute an adequate sample in most instances. For length-of-transpiring-day comparisons, 2 trees would suffice. This number of samples can be easily handled by one person, with one instrument, on an hourly sampling sequence.

273. SWANSON, R.H. Velocity distribution patterns in ascending xylem sap during

transpiration.
Flow, 1974, 1: 1425-1430
Subject Codes: 8.8.3
LISC: 584973

The ascending sap stream of trees exhibits flow properties analogous to flow in pipes. Data collected from lodgepole pine and Engelmann spruce from 1960 to 1970 suggests that the flow is laminar and its velocity distribution parabolic. In conifers, sap ascends through tracheids more or less uniformly distributed across a cylindrical band of comparatively wet sapwood surrounding a cylinder of physiologically inactive dry heartwood. The diameter of the void area in individual tracheids is larger at the centre of this band of sapwood than at either the bark or heartwood interphases. Thus the size of the sap conducting elements are themselves distributed in a somewhat parabolic distribution is not known. An important application of this finding lies in the measurement of water use by trees in forest hydrology research. Two heat pulse velocity measurements (measurements used to estimate sap flow rates) made simultaneously at specified but unequal depths are sufficient to describe both average flow velocity and the cross sectional area through which such flow occurs. Thus both the "A" and "V" of the continuity equation are described in a flow system within which the conducting cross section varies with time.

274. SWANSON, R.H. Water use by mature lodgepole pine. IN: Proceedings, Management of Lodgepole Pine Ecosystems Symposium.
Wash. State Univ., Coop Extension Serv., Pullman, WA, 1975: 264-277
Subject Codes: N/A
LISC: 590778

Transpiration by individual lodgepole pine (Pinus contorta) trees varied from 2 l/day during Sept. in Alberta to 91 l/day during Feb. in New Zealand. The average clear day water use by each tree during summer in Colorado is 22.7 l, in Alberta 8.8 l, and in New Zealand 44.4 l. The annual water use by a mixed stand of lodgepole pine and Engelmann spruce in Colorado was 292 mm of which the lodgepole pine portion used 138 mm. A thinned stand of Alberta lodgepole pine transpired 170 mm while the unthinned counterpart used 239 mm. The annual water use by a particularly well-watered plot of lodgepole pine in New Zealand was 1 100 mm, with that from more normally watered sites 370 to 400 mm. There is no absolute standard against which the water use of an individual lodgepole pine tree or stand can be judged. As incident solar radiation supplies most of the energy for transpiration, it is suggested as a possible standard for stands. Since actual solar radiation figures were not available, a potential figure based on the theoretical clear sky radiation and precipitation data is defined for this paper as the monthly clear sky radiation incident on any given site reduced by the number of days during the month that the precipitation is greater than 2.5 mm. This "standard" applied to the Alberta and New Zealand summer transpiration rate indicates that sites where the trees utilize approx. 20% of the potential insolation may be operating at near maximum efficiency for diameter growth. Daily and seasonal transpiration values are site and time specific.

275. WAMBOLT, C.L. Conifer water potential as influenced by stand density and environmental factors.
Canadian Journal of Botany, 1973, 51(12): 2333-2337
8 ref.
Subject Codes: N/A
CAB: 371679

The relation between tree density and leaf water potential (....i) in 14 stands of Juniperus osteosperma and J. scopulorum (homogeneous with regard to other factors that could influence...i , e.g. slope, exposure, and soil) was evaluated by multiple regression and correlation analysis, and the two factors were shown to be highly significantly correlated. This was interpreted as quantitative evidence of intraspecific competition for available moisture by plants. Further measurements were made of a number of site variables in three stands each of J. osteosperma, J. scopulorum, Picea engelmannii, Pinus contorta, P. flexilis, P. ponderosa and Pseudotsuga menziesii, in Wyoming, and significant correlations were found between ....i and altitude, sand %, temperature, r.h. and vapour pressure deficit, even though the stands were in widely divergent habitats.

276. YAVITT, J.P., FAHEY, T.J. 1985. Chemical composition of interstitial water in decaying lodgepole pine (Pinus contorta ssp. latifolia) bole wood. Canadian

Journal Forest Research. 15(6):1149-1153.

The chemical composition of interstitial water in highly decayed lodgepole pine (Pinus contorta ssp. latifolia) bole wood lying on the forest floor was sampled during the spring snow melt period in 1981 and 1982. The solutions were dominated by nutrient-rich organic compounds, and more than 95% of the dissolved total N and P occurring in organically bound forms. Relatively low C:N (45:1) and C:P (280:1) ratios for these organic compounds were 4- and 12-fold lower than C:N and C:P ratios for the solid phase, respectively, suggesting that they were preferentially mineralized by heterotrophic microorganisms. Subsequent rapid absorption by tree roots and microbes during the snow melt period probably was responsible for maintaining the low inorganic N and P concentrations that occurred. Presence of soluble polyphenols and carbohydrates, primary components of the lignocellulose wood substrate, suggest that the dissolved organic compounds resulted in part from the incomplete oxidation of organic matter decay products. Soluble organic ligands accounted for more than 65% of the solution charge balance. Although 80% of the dissolved organic carbon was acidic in nature, solution pH values were rather higher (5.4), in part because of high concentrations of base cations.

## 3.0 E C O L O G Y

277. BAER, N.W. Soil water relations of lodgepole pine.
Dissertation Abstracts International, B, 1976, 36(8): 3696
Subject Codes: 3.6, 8.8.3
CAB: 903510

Growth chamber experiments with lodgepole pine (Pinus contorta) seedlings showed that transpiration became negligible at 8.7% soil m.c. (soil water potential -15.2 bar). For evaporation from the soil surface, the values were 8.9% and -17.6 bar. Needle tissue lost viability when the soil m.c. was 4.9-5.8%. Experiments with polyethylene glycol showed that at a water potential of about -20 bar, roots of P. contorta seedlings were apparently unable to absorb water: transpiration ceased and the seedlings died within a week. Field trials in the Bighorn National Forest (Colorado), were also performed, to determine the effects of water, shade and seedling size on the survival of planted 2 + 0 seedlings. In a wet season (1973), none of these variables affected survival, but in a dry season (1974), it was significantly increased by shading.

278. BEIL, C.E. Ecology of grassland communities in the Caribou aspen, lodgepole pine, Douglas-fir zone, British Columbia, Canada. IN: Abstracts of the Papers Presented at the XI International Botanical Congress and the International Wood Chemistry Symp. 260 pp XI International Botanical Congress, Seattle, WA, USA, 1969: 12
Subject Codes: 3.4
BIO: 69081076

279. BERGEN, J.D. Vertical profiles of wind speed in a pine stand.
For. Sci., 1971, 17(3): 314-321
Subject Codes: 6.4
BIO: 53007757

280. BERGEN, J.D. Air movement in a forest clearing as indicated by smoke drift.
Agricultural Meteorology, 1975, 15(2): 165-179
14 ref., 3 pl.
Subject Codes: 6.5
CAB: 928224

Observations were made in 1971 and 1972 on the behaviour of multiple smoke plumes in an isolated clearing (10 x 80 m) cut in an even-aged stand (avg. height 10 m) of lodgepole pine (Pinus contorta) in Wyoming. The air movement in the clearing alternated between an unseparated flow and a central vortex motion similar to that found in a square notch. The transition involved a strong circulation along the crosswind axis of the clearing. Air speed and turbulence were greatest during the vortex flow.

281. DESPAIN, D.G. Vegetation of the Big-horn Mountains, Wyoming, in relation to substrate and climate.
Ecol. Monogr., 1973, 43(3): 329-355
Subject Codes: N/A
BIO: 57048290

282. FRANKLIN, J.F., DYRNESS, C.T. Natural vegetation of Oregon and Washington.
Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Portland, Oregon, USDA Forest Service General Technical Report PNW-8, 1973: 417 pp.
Subject Codes: N/A
RCA: X1021

This report presents the major vegetation types within the States of Oregon and Washington. In it are outlined the major phytogeographic units and their relation to environmental factors. Sources of detailed information on the environment and vegetation of the Pacific Northwest are provided. Photographs illustrating the major plant communities are included.

283. HORN, E.M. Ecology of the pumice desert Crater Lake National Park, USA lodgepole pine.
Northwest Sci., 1968, 42(4): 141-149
Subject Codes: 2.11
BIO: 50101714

284. LOTAN, J.E., PERRY, D.A. 1983. Ecology and regeneration of lodgepole pine. Intf&Res, USDA Forest Service, Missoula, MT, USA. Agriculture Handbook. V+51 p.

A comprehensive review of the literature, with emphasis on practical applications.

285. MACK, R.N., RUTTER, N.W., BRYANT, V.M. JR., VALASTRO, S. Reexamination of postglacial vegetation history in northern Idaho, USA, Hager Pond, Bonner County.
Quat. Res. (N.Y.), 1978, 10(2): 241-255
Subject Codes: N/A
BIO: 67036774

Hager Pond, a mire in northern Idaho (USA) reveals at least 5 pollen zones since sediments formed after the last recession of continental ice (9500 yr B.P.). Zone I (9500-8300 yrs B.P.) consists mainly of diploxylon pine, plus low percentages of Abies, Artemisia and Picea. SEM (scanning electron microscopy) examination of conifer pollen at selected levels in the zone reveals that Pinus albicaulis, P. monticola and P. contorta are present in unknown proportions. The zone resembles modern pollen spectra from the Abies lasiocarpa-P. albicaulis association found locally today only at high elevation. Presence of whitebark pine indicates a cooler, moister climate than at present, but one which was rapidly replaced in Zone II (8300-7600 yr B.P.) by warmer, drier conditions as inferred by prominence of grass with diploxylon pine. Zone III (7600-3000 B.P) was probably dominated by Pseudtosuga menziesii, plus diploxylon pine and prominent Artemisia and denotes a change in vegetation but continuation of the warmer drier conditions. Beginning at 3000 yr B.P. Picea engelmannii, A. lasiocarpa and/or A. grandis and diploxylon pine were dominants and the inferred climate became cooler and moister concomitant with Neoglaciation. The modern climate climax (Zone V), with Tsuga heterophylla as dominant, has emerged in approximately the last 1500 yr.

286. MATTSON, W.J. (Editor) The role of arthropods in forest ecosystems.
New York, USA, Springer-Verlag, New York, Inc., 1977: x + 106 pp.
many ref., 3 pl.
Subject Codes: 6.1
CAB: 856455

A collection of 12 papers from a symposium at the 15th International Congress of Entomology, Washington, D.C. Aug. 19-27, 1976, including the following of forestry interest: Amman, G.D. The role of the mountain pine beetle in lodgepole pine ecosystems: impact on succession. It is concluded that Dendroctonus ponderosae has exploited the niche of 'harvesting' Pinus contorta var. latifolia at or slightly before maturity, thus maintaining the productivity of the stand. Heinrich, B. Pollination energetics: an ecosystem approach. Crossley, D.I., Jr. The roles of terrestrial saprophogous arthropods in forest soils: current status of concepts. McBrayer, J.F. Contributions of cryptozoa to forest nutrient cycles. Dindal, D.L.; Metz, L.J. Community structure of Collembola affected by fire frequency.

287. MILES, S.R., SINGLETON, P.C. Vegetative history of Cinnabar Park in Medicine-Bow National Forest, Wyoming, USA.
Soil. Sci. Soc. Am. Proc., 1975, 39(6): 1204-1208
Subject Codes: N/A
BIO: 61054144

288. MINORE, D. Effects of artificial flooding on seedling survival and growth of 6 northwestern USA tree species: Douglas-fir, Sitka spruce, hemlock, red cedar, lodgepole pine, red alder.
US Forest Serv. Research Note, 1968, PNW-92: 1-2

Subject Codes: N/A
BIO: 69032160

289. NYLAND, E. Lodgepole pine in the Yukon. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 27-43
Subject Codes: 1.5, 3.1
RCA: X1080

This paper describes lodgepole pine seed, seed production and rooting problems with respect to the Yukon climate. The advantages of using Yukon-origin Pinus contorta seed are discussed.

290. POJAR, J. 1985. Ecological classification of lodgepole pine in Canada. Pages 77-88 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

The most pervasive ecological classification within the Canadian range of lodgepole pine is a biogeoclimatic ecosystem classification adapted by the Alberta and British Columbia Forest Services from the pioneering work of V. J. Krajina and his students. The taxa result from a synthesis of climate, vegetation, and soil data. The system includes ecosystem units (associations, subassociations, types), which are synthesized from individual ecosystems or biogeocoenoses, and biogeoclimatic units (zones, subzones, variants), which represent geographical areas. Zonal or climatic climax associations characterize subzones, and provide the link between the two types of units. British Columbia and Alberta are presently divided into 17 or 18 biogeoclimatic zones and numerous subzones. Lodgepole pine occurs in all but three of these zones, but is most abundant in cool, montane and subalpine, interior portions of the Canadian Cordillera. Lodgepole pine functions as a possible climatic climax species in only one area, a cold, dry subzone in the Chilcotin district of B.C. Although traditionally viewed as a seral species, lodgepole pine could be interpreted as a major component of "climax" vegetation where frequent, large-scale disturbance is normal. The classification of one subzone of the Sub-Boreal Spruce Zone is outlined at the ecosystem level. Floristic and habitat features are summarized for three of the ten forest associations that have been differentiated in the subzone. Silvicultural interpretations linked to the classification involve reforestation, tree species selection, site preparation, brush hazard, stock type, stocking standards, and density control. Aids to ecosystem identification and interpretation include maps, descriptions, keys, habitat grids, topographic sequences, guides to plant identification, outlines of management recommendations, and an active training program. Future research needs include completion of the initial classification; classification of seral ecosystems; studies on succession, energy and biogeochemical cycling, site productivity, and impacts of management on these processes; and a system of ecological reserves.

291. REHFELDT, G.E. Cold acclimation in populations of pinus-contorta from the northern Rocky Mountains, USA.
Bot. Gaz., 1980, 141(4): 458-463
Subject Codes: 1.4, 3.1, 6.4, 7.3
BIO: 72001816

Freezing tests were conducted to follow cold acclimation in seedlings representing 30 populations of P. contorta from the northern Rocky Mountains. For each of 12 dates from Aug. - Nov., leaves from 2-yr-old seedlings growing in a common environment were frozen at 4 test temperatures. Injury from freezing was scored primarily by tissue discoloration. Hardiness of populations developed in a slow and uniform pattern. Mean differences in the hardiness of populations were readily detected throughout acclimation, and the relative ranking of populations for hardiness remained essentially constant. Elevation and geographic region of the seed origin accounted for 78% of the variance in hardiness among populations.

292. SANDERSON, J.E., et al. Proceedings, Tall Timbers Fire Ecology Conference No. 14 and Intermountain Fire Research Council Fire and Land Management Symposium, Oct. 8-10, 1974, Missoula, Montana.
Tallahassee, Fla., USA; Tall Timbers Research Stn., 1976, ix + 675 pp.
many ref.

Subject Codes: 6.3
CAB: 816914

At the joint meeting on fire and land management 32 papers were presented in three sections. The Fire Management Section contained 10 papers including five related to specific fire management in Rocky Mountain, Grand Teton, Yellowstone and Glacier National Parks, and the following: Sanderson, J.E. The role of fire suppression in fire management. Devet, D.D. Descon (designated control burning system): utilizing benign wildfires to achieve land management objectives. Eleven papers were presented in the Fire Ecology Section, including: Bock, J.H.; Bock C.E.; Hawthorne, V.M. Further studies of natural reforestation in the Donner Ridge Burn. Kickert, R.M.; Taylor, A.R.; Firmage, D.H.; Behan, M.J. Fire ecology research needs, identified by research scientists and land managers. Lotan, J.E. Cone serotiny - fire relationship in lodgepole pine (Pinus contorta). Wicker, E.F.; Leaphart, C.D. Fire and dwarf mistletoe (Arceuthobium spp.) relationships in the northern Rocky Mountains. Parmeter, J.R., Jr.; Uhrenholdt, B. Effects of smoke on pathogens and other fungi. Lyon, L.J.; Stickney, P.F. Early vegetal succession following large nothern Rocky Mountain wildfires.

293. SATTERLUND, D.R. Climatic factors and Lodgepole Pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 297-309
32 ref.
Subject Codes: 6.4
CAB: 757461

Classical climatic classifications are of little value in the management of Pinus contorta because of its tolerance of wide variation in climatic factors. It is suggested that a study of climatology in terms of energy balances would be more useful.

294. SHEPPARD, J.S. The influence of geo-thermal temperature gradients upon vegetation patterns in Yellowstone National Park, USA.
Diss. Abstr. Int., B, Sci. Eng., 1971, 32(3): 1403-B
Subject Codes: 3.1
BIO: 72093099

295. TAYLOR, D.L. Some ecological implications of forest fire control in Yellowstone National Park, Wyoming.
Ecology, 54(6), 1973: 1394-1396
Subject Codes: 6.3
BIO: 57024799

296. TESCH, S.D. Comparative stand development in an old growth Douglas-fir Pseudotsuga-menziesii-var-glauca forest in western Montana, USA.
Can. J. For. Res., 1981, 11(1): 82-89
Subject Codes: 1.5, 3.4
BIO: 72051179

The composition, structure and reproductive dynamics for 2 old-growth Douglas-fir (P. menziesii var. glauca (Beissn.) Franco) stands, located on opposing north and south aspects, were analyzed to reconstruct their past developmental patterns. Results indicate that the north aspect stand developed an even-aged structure intially and shifted to an uneven-aged structure over time. The theory of monospecific dominance by the climax species is supported on the north aspects as Douglas-fir maintains the highest importance value of all species present. The competitive exclusion principle appears inappropriate in this case as lodgepole pine (Pinus contorta Dougls.), an intolerant, seral dominant, is reproducing successfully under the old-growth canopy. The south aspect stand has developed an uneven-aged structure and maintains it as harsh environmental conditions limit reproductive success to favorable microsites, precluding complete canopy closure.

297. VOLLAND, LEONARD A. 1985. Ecological classification of lodgepole pine in the United States. Pages 63-75 in Lodgepole pine: the species and its management.

Symposium proceedings. Washington State University, Pullman, WA.

Literature relating to ecological classification of lodgepole pine in the United States is reviewed with emphasis being placed on the last 15 years. The Review discusses ecological status of the species and importance of lodgepole pine site classification to resource management considerations. These classifications usually relate to the successional status of lodgepole pine and how the investigator perceives the position of the species in that context. The species occurs in three distinctly different ecological niches across its geographic range: (1) as a seral species to more shade tolerant tree species, (2) as a relatively stable codominant with one or more other species, and (3) as the only tree layer dominant. Characteristics which influence the seral status of lodgepole pine include its wide ecological amplitude, the frequency of stand disturbance and size of the area being disturbed. Successional development where lodgepole is either seral or persistent usually follow multiple pathways depending upon associated species and stand history. Climax sites have topographic and/or edaphic characteristics considered too harsh for successful establishment of other species. A stratification of lodgepole environments permits management to be directed to those sites where resource values, risk to stand deterioration, or opportunities for species manipulation are the greatest. The plant community is one way of achieving this stratification since information affecting lodgepole management decisions (critical environmental controls and successional trends) are inherent to the community. Another approach is to correlate population studies of size or age distributions by species with stand historical information.

298. ZIMMERMAN, G.T., LAVEN, R.D. 1984. Ecological interrelationships of dwarf mistletoe arceuthobium-americanum and fire in lodgepole pine Pinus contorta forests. American Journal of Botany. 71(5):61.

## 3.1 PHYSIOGRAPHY

299. BEIL, C.E. Forest associations of the southern Cariboo Zone, British Columbia.
Syesis, 1974, 7: 201-234
35 ref.
Subject Codes: 1.5, 3.0, 3.2, 3.4, 3.5, 3.6
CAB: 594638

A plant-sociological classification is presented for the forest vegetation of the area. Nine associations are recognized and described; their distribution appears to be controlled primarily by topography and soil texture. The major tree species present are: Pseudotsuga menziesii, Picea glauca, Pinus contorta and Populus tremuloides. The associations described are compared floristically with similar community types from other parts of British Columbia, western Alberta and the north-western USA.

300. BELLEFLEUR, P. Markov models of forest type secondary succession in coastal British Columbia, Canada.
Can. J. For. Res., 1981, 11(1): 18-29
Subject Codes: 3.2, 3.4
BIO: 72051178

Sample plots of 5 biogeoclimatic subzones of the British Columbia coastal forest were classified into forest types at 5 yr intervals during 40 yr (Major species were Tsuga heterophylla, Pseudotsuga menziesii, Thuja plicata, Picea sitchensis, Abies grandis, A. amabilis, Alnus rubra and Pinus contorta). Matrices of transition probabilities from 1 forest type to another were calculated and stationary Markov models were built for each subzone. Simulation runs were tested against observations. The time and composition of steady state were predicted to evaluate the likelihood of the models. Succession and behaviour of forest types were discussed within and between subzones. Forest succession was not Markovian for reasons that depended solely on the data set and on properties of stationary Markov models. The future of a forest type cannot be determined solely on the basis of its present state, and its prediction necessitates a sound knowledge of how the forest got there in the first place.

301. CHRISTIE, J.M., LINES, R. A comparison of forest productivity in Britain and Europe in relation to climatic factors.
Edinburgh, UK, Forestry Commission, 1975, 34 pp.
many ref.
Subject Codes: 5.0
CAB: 662874

Compares the growth of Pinus contorta, P. sylvestris, Picea abies and P. sitchensis in various countries on the basis of national yield tables. An introductory section deals with types of climate in Britain, northern Europe and north-western N. America with particular reference to length of growing season, accumulated temperature, frost-free season, day-length, and availability of water. The productivity of each species is attributed in part to direct climatic effects or climatic/genotype interactions which appear to be manifested in two clinal patterns: (a) latitudinal, with increased growth at lower latitudes and (b) a longitudinal cline from oceanicity to coninentality, with differing effects on different species. The remainder of the variation is attributed to differences in soil factor, provenance, stocking or silvicultural treatment. It is concluded that the productivity of these species in Britain compares favourable with that in northern Europe and north-western N. America.

302. DESPAIN, D.G. Geological influences on the forest vegetation of the Bighorn Mountains of Wyoming.
Am. J. Bot., 1971, 58(5 part 2): 482
Subject Codes: N/A
BIO: 72007023

303. MASSER, C., MATE, B.R., FRANKLIN, J.F., DYRNESS, C.T. Natural history of Oregon coast mammals.
Gen. Tech. Rep., Pacific Northwest Forest and Range Experiment Stn., USDA Forest Service, 1981: PNW-133 xix + 496 pp.
33 pp. ref., 31 pl.
Subject Codes: 6.6
CAB: 1539837

The geology and soils, vegetation and habitats, and land and marine mammals of the area are described. Habitats include coniferous and broadleaved forests and communities of lodgepole pine, sitka spruce/salal (Gaultheria shallon), lodgepole pine/rhododendron, and lodgepole pine/salal on stabilized sand dunes.

304. MOIR, W.H. The lodgepole pine - Pinus contorta - zone in Colorado, USA.
Amer. Midland Natur., 1969, 81(1): 87-97
Subject Codes: N/A
BIO: 50039838

305. PARKER, A.J. Comparative structural functional features in conifer forest of Yosemite and Glacier National Parks, USA.
Am. Midl. Nat., 1982, 107(1): 55-68
Subject Codes: N/A
BIO: 74053437

Structural/functional characteristics of the vegetative cover are used to provide common attributes for comparing vegetation patterns in Yosemite National Park, California, in the central Sierra Nevada, and Glacier National Park, Montana, in the northern Rocky Mountains. Ordinations based on composition allow identification of 4 forest types in Yosemite: ponderosa pine/incense-cedar forests in xeric, lower montane sites, white fir/incense-cedar forests on mesic, lower montane sites; red fir/white fir forests on mesic, upper montane sites and lodgepole pine forests on mesic, upper montane sites and lodgepole pine forests on subalpine sites. These types segregate along an elevational gradient. Compositional ordinations allow identification of 3 forest types in Glacier: red cedar/hemlock forests on moist sites; ponderosa pine/Douglas fir forests on dry sites and lodgepole line/larch forests on intermediate moisture sites. Within the limited elevation zone sampled, geographic moisture differences and associated disturbance phenonema overshadow the influence of elevation in controlling vegetation patterns in Glacier. Structural/functional ordinations produce stand arrangements similar to compositional ordinations for each region and are

interpreted according to variations in significant structural/functional factors along an elevational gradient in Yosemite and a successional gradient in Glacier. Differences in the control of forest structure between regions are attributed to climatic disparities and associated differences in disturbance regimes.

306. WEAVER, T., PERRY, D. Relationship of cover type to altitude, aspect and substrate in the Bridger Range, Montana.
Northwest Science, 1978, 52(3), part 1: 212-219
Subject Codes: 1.5, 3.5, 3.6
CAB: 984215

The relationship was explored by comparing mapped data for 555 systematic sample points on topographic, geological and vegetation cover type maps (produced by the US Geological Survey and the US Forest Service). The study area was at 1678-2593 m alt. (rarely higher): Douglas-fir (Pseudotsuga menziesii) forests were predominant, with grasses and shrubs important at low alt. (1678-1983 m) and on ESE and SSW slopes, and subalpine fir (Abies lasiocarpa) above 2 288 m. Lodgepole pine (Pinus contorta) occurred at all altitudes, but only on NNE and ESE aspects. Douglas-fir cover types were found on limestone and gneiss, grasses on sandstone, and lodgepole pine on interbedded sandstone and shale; subalpine fir avoided gneiss. Silvicultural aspects are discussed.

307. WIDDEN, P., PARKINSON, D. Fungi from Canadian coniferous forest soils.
Can. J. Bot., 1973, 51(12): 2275-2290
Subject Codes: N/A
BIO: 57063835

308. WIRSING, J.M., ALEXANDER, R.R. Forest habitat types on the Medicine Bow National Forest, southeastern Wyoming: preliminary report.
USDA For. Serv. Gen. Tech. Report, Rocky Mountain For. and Range Exp. Stn., 1975, No. RM-12: 11 pp.
17 ref.
Subject Codes: N/A
CAB: 556430

Briefly describes five forest types: Abies lasiocarpa/Vaccinium scoparium, including the Pinus contorta/V. scoparium community; A. lasiocarpa/Carex geyeri, including the P. contorta/C. geyeri community; Populus tremuloides/C. geyeri/ Pinus ponderosa/C. geyeri; and Pinus flexilis/C. geyeri.

## 3.2 HISTORY

309. AMMAN, G.D., BAKER, B.H. Mountain pine beetle influence on lodgepole pine stand structure.
J. For., 70(4), 1972: 204-209
Subject Codes: 6.1
BIO: 72057193

310. ARNO, S.F. The historical role of fire on the Bitterroot National Forest.
USDA For. Serv. Res. Paper, Intermountain For. & Range Exp. Stn., 1976, No. INT-187: 29 pp.
19 ref., 1 pl.
Subject Codes: 6.3
CAB: 939686

Fire-scarred trees were sampled along transects of 3 study areas representing a wide range of alt., aspect and terrain in the Bitterroot National Forest, Montana. Data are tabulated for the apparent years (from annual ring counts) in which fire occurred and the number of trees scarred in each stand. Ponderosa pine (Pinus ponderosa), Douglas-fir (Pseudotsuga menziesii), western larch (Larix occidentalis), lodgepole pine (Pinus contorta) and whitebark pine (P. albicaulis) had multiple scars dating back 250-300 years; P. ponderosa had the clearest, most abundant and oldest (to 400 years) records. Fire areas are reconstructed for

one study area since 1734. Low-intensity ground fires occurred frequently until 1900 and left substantial remnants of earlier age classes standing. Fire frequency generally decreased with increasing alt. Evidence is presented for aboriginal burning as a major fire cause. Fire exclusion has reduced the incidence of fire over the past 50 years, resulting in accumulation of fuel in many stands. Prescribed burning is recommended to reduce the risk of high-intensity wildfire.

311. ARNO, S.F. Forest fire history in the Northern Rockies.
Journal of Forestry, 1980, 78(8): 460-465
32 ref.
Subject Codes: 6.3
CAB: 1329561

Recent fire-scar studies documenting fire history as early as 1500 are reviewed, and mean fire-free intervals summarized for areas of 7 potential climaxes (Pinus ponderosa, Pseudotsuga menziesii, Pinus contorta, Abies grandis, Thuja plicata/Tsuga heterophylla and 2 Abies lasiocarpa types), giving the species usually favoured by fire. In some forests, fire maintained many-aged open stands of seral trees, while in others, major fires caused replacement of stands. Often, however, variable intensity of burn caused a mosaic of stands differing in composition and structure.

312. COCHRAN, P.H. Lodgepole pine - clearcut size affects minimum temperatures near the soil surface.
U.S. Forest Serv. Research Paper PNW-86, 1969: 1-9
Subject Codes: N/A
BIO: 51045979

313. COLE, D.M. Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: some management implications.
Biological Conservation, 1981, 20(4): 247-270
73 ref., 1 pl.
Subject Codes: 6.3, 8.4, 8.8.2
CAB: 1557231

Vegetation reduction by trampling was confined to a zone (4 m wide on either side of trails). Ground cover loss was 90-96% in forested campsites, compared with 40-64% in non-forested campsites, with associated soil compaction and erosion, and exposure of tree roots. Fire suppression, particularly at lower altitudes, has inhibited regeneration of fire tolerant species including Pinus ponderosa, Larix occidentalis, Pseudotsuga menziesii, Picea engelmanii and P. contorta, and favoured regeneration of Pinus albicaulis and Abies lasiocarpa. Suggestions are made for management.

314. DEBENEDETTI, S.H., PARSONS, D.J. National fire in subalpine meadows: a case description from the Sierra Nevada.
Journal of Forestry, 1979, 77(8): 477-479
13 ref., 2 pl.
Subject Codes: 6.3
CAB: 1329562

An account of the lightning-ignited fire that burned Ellis meadow (alt. 8800 ft.) in Kings Canyon National Park, California during a severe drought in July, 1977. It is suggested that natural fires are important in maintaining the forest/meadow boundary (e.g. by differential mortality of lodgepole pike, as shown here), and that such fires should be allowed to burn when possible.

315. FOWLER, W.B., HELVEY, J.D. Changes in the thermal regime after prescribed burning and select tree removal (Grass Camp, 1975).
USDA For. Service Res. Paper, Pacific NW For. & Range Exp. Stn., 1978, No. PNW-234, 17 pp.
5 ref. 3 pl.
Subject Codes: 3.6, 7.6
CAB: 1286253

Soil temp. and air temp. up to ht. 7 m were monitored at 2 test sites and a control site (alt. 1730 m) in the Wenatchee National Forest, during and for 2 yr. after prescribed burning in Sept. 1975; test site (a) was a grassy slope with invading lodgepole pine (also treated by felling small trees shading the site), and test site (b) was an older spruce/fir snag thicket with accumulated dead standing and windthrown trees. The control site showed a trend to cooler and less variable soil and air temp. in 1976, while both test sites showed moderate increases in max. air temp. at 0.5 m and large increases in max. soil temp. at 0.01 m (8 deg C for (a) and 26 deg C for (b)). The data are analyzed by double mass plots of accumulated degree hours which give an indication of trends with revegetation.

316. GALLAGHER, G.J. Crop structure studies in Ireland. IN: Growing Space in Coniferous Crops.
Irish Forestry, 1980, (37): 5-32
many ref.
Subject Codes: 7.6.2, 7.7
CAB: 1369085

A review of over 40 stand-structural studies undertaken by the Forest and Wildlife Service in 1958-1979, mostly involving Sitka spruce and lodgepole pine. Some of the spacing experiments have now reached first thinning, and some thinning experiments are approaching rotation age. Data collection and storage have been described elsewhere. As yet there are few data on increased wind stability of stands established at wide spacings vs thinned stands. Survival and diameter and volume increments were analyzed and compared with published spacing and thinning experiments from other parts of the world. The economic benefits of increased growing space are discussed in relation to possible reductions in quality.

317. GARY, H.L. The vertical distribution of needles and branchwood in thinned and unthinned 80-year old lodgepole pine.
Northwest Science, 1978, 52(4): 303-309
10 ref.
Subject Codes: 5.1, 7.7
CAB: 1380490

Adjacent thinned and unthinned areas in a S. Wyoming forest were studied about 30 years after thinning, to compare DM production of needles and branches and the distribution of their weights within the canopy. Weight distribution was determined using a Weibull density function. In the thinned area, the observed and theoretical weight, distribution of both needles and branchwood was symmetrical and normally distributed. In the unthinned area, weight distribution was strongly skewed upward in the top half of the canopy. In the thinned area, d.b.h. averaged twice that of trees in the unthinned area and height was 25% greater.

318. JOHNSTONE, W.D. Ingress of lodgepole pine and white spruce regeneration following logging and scarification in west-central Alberta.
Info. Rep., Northern For. Res. Centre, Canada, 1976: No. NOR-X-170, iii + 12 pp.
7 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.1, 7.6.1
CAB: 928094

The number of surviving seedlings of white spruce (Picea glauca) and lodgepole pine (Pinus contorta var. latifolia) germinating in each year was determined in 36 clear- felled plots in Alberta that had been scarified at least 11 years previously. Ingress of spruce and pine continued for up to 11 and 13 growing seasons, respectively, after scarification. The results indicate that stocking is improved by prompt scarification after logging and that present survey timing and established seedling standards underestimate stocking. It is recommended that surveys be conducted at the end of the eighth growth season after logging and that all seedlings be included.

319. LOOPE, L.L. GRUELL, G.E. The ecological role of fire in the Jackson Hole area,

northwestern Wyoming.
Quat. Res. (N.Y.), 1973, 3(3): 425-443
Subject Codes: 3.6
BIO: 74019701

320. LYON, L.J. Attrition of lodgepole pine snags on the Sleeping Child Burn, Montana. USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1977, No. INT-219: 4 pp.
4 ref.
Subject Codes: 5.0, 6.3
CAB: 939693

Snags, mainly Pinus contorta, in a 28000 acre burn at 6400-7200' were recorded in 4 diam. classes 1 year after burning in 1962 and periodically until 1976. In the first 2 years after burning there was a loss of only 1-2% of snags/year. Snag fall then increased and was relatively constant for small snags in subsequent years. Percentage fall averaged 27.9%/year and 8.4%/year for snags of less than 3" d.b.h. and snags of 3-8" d.b.h., respectively. Attrition of snags greater than 8" in diameer averaged 8.6%/year but was not constant from year to year. By 1976, only 1.4% of snags less than 3" d.b.h. and 15% of total snags remained standing.

321. MOTT, R.J., JACKSON, L.E. Jr. An 18000 year palynological record from the southern Alberta, Canada, segment of the classical Wisconsian ice-free corridor.
Can. J. Earth Sciences, 1982, 19(3): 504-513
Subject Codes: 3.4, 3.5
BIO: 74048650

Radiocarbon dates of 18,300 .+-. 380 years BP (GSC-2668) and 18,400 .+-. 1090 years BP (GSC-2670) on moss fragments from the clay near the base of a core from Chalmers Bog, Alberta indicate that the classical Wisconsian Ice-free Corridor was in existence in the foothills of southern Alberta by this time. Palynological studies show sparse, herbaceous, tundra-like vegetation probably prevailed at this time in the area surrounding the small lake formed in the abandoned glacial spillway. Later, shrubs became more prominent to form a shrub tundra environment. Sometime before 8220 years BP (GSC-2851), trees began to invade the area, and the Pinus contorta dominated coniferous forest extant in the area today began to form. Bog and fen vegetables invaded the shallow lake basin about this time also to form the bog ;that occupies the basin to the present day.

322. MULLER, R.A. Transmission components of solar radiation in pine stands in relation to climatic and stand variables.
US For. Serv. Research Paper PSW-71, 1971: 1-13
Subject Codes: N/A
BIO: 54019470

323. PEET, R.K. Forest vegetation of the Colorado front range, USA: composition and dynamics.
Vegetation, 45(1): 3-75
Subject Codes: 3.4
BIO: 73009102

The forest vegetation of the northern Colorado Front Range was studied using a combination of gradient analysis and classification methods. A graphical model of forest composition based on elevation and topographic-moisture gradients was constructed using 305 0.1 ha samples. To derive the topographic-moisture gradient, stands were stratified into eight 200 m elevation belts and ordinated by correspondence analysis using understory ( 1m) data. Each of the resultant gradients was scaled against a standard site moisture scalar derived from incident solar radiation and topographic position. Except for krummholz sites, the vegetation defined gradients fit the moisture scalar closely. Once scaled, these gradients were stacked vertically, sandwich-style, to create the graphical representation. On favorable, middle-elevation sites, trees become established rapidly after disturbance. Rapid growth results in severe overcrowding and competitive elimination of reproduction. As a consequence bell- shaped diameter distributions develop. Diversity and productivity appear to drop while biomass remains roughly constant. Following decades or even centuries of stagnation, the forests eventually breakup through mortality of the canopy trees, allowing regeneration to resume. During this period of renewed regeneration, biomass,

diversity and productivity all show dramatic changes in response to the changing population structure. This type of forest development can be found in forests dominated by Picea engelmannii, Pinus flexilis or Populus tremuloides. On highest elevation forest sites or at middle elevations on the very driest sites reestablishment rates are greatly reduced. These forests dominated by Picea and Abies or Pinus flexilis gradually approach predisturbance levels of biomass, diversity and productivity, while regeneration remains at a roughly constant level. At lower elevations in the Pinus ponderosa woodlands, regeneration appears episodic, reflecting variation in seed rain and favorable conditions for seedling growth. Inter-tree competition is relatively unimportant and diameter distributions show irregular humps resulting from periodic recruitment.

324. STRINGER, P.W., LA ROI, G.H. The Douglas-fir forests of Banff and Jasper National Parks, Canada.
Can. J. Bot., 1970, 48(10): 1703-1726
Subject Codes: N/A
BIO: 52013245

325. STUTH, J.W. Livestock, deer and logging interactions in the lodgepole pine-pumice region of central Oregon.
Disseration Abstracts International, B, 1975, 36(5): 1995-1996
Subject Codes: 3.6, 8.8
CAB: 564601

Reports studies in summer 1973 (dry) and 1974 (wet) in meadow communities and logged and unlogged areas on the Pinus contorta/Purshia tridentata/Stipa occidentalis habitat type. Grazing of Purshia tridentata by cattle, sheep and deer in logged and unlogged areas, and the effects of logging on P. tridentata, are described.

326. U.S.D.A. FOREST SERV. Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. Symposium Proceedings, Sept. 11-13, 1979, Missoula, Mont.
Gen. Tech. Rep., Intermountain For. & Range Exp. Stn., USDA Forest Service, 1980, No. INT-90: 526 pp.
many ref., 24 pl.
Subject Codes: 8.4
CAB: 1407159

After a brief introductory section, 23 papers are included in 3 sections: basic environmental responses (effects of harvesting on nutrient cycling, microbiology, hydrology); biological implications (effects of harvesting, residue utilization and fire on arthropods, understorey vegetation, disease); resource management implications (fuels, wildlife, aesthetic effects). Most papers refer to research on the lodgepole pine, larch and Douglas-fir forests of Wyoming and Montana.

## 3.3 NUTRIENT

327. BAKER, J. Nutrient levels in rainfall, lodgepole pine foliage, and soils surrounding two sulfur gas extraction plants in Strachan, Alberta.
Info. Rep., Northern For. Res. Ctre., Canada, 1977, No. NOR-X-194: 18 pp.
22 ref.
Language: en
Summary Languages: fr
Subject Codes: 6.5
CAB: 1377647

Needle and twig tissues from Pinus contorta(40-60 years old) on SO2-exposed sites contained greater amounts of S and Al but less Ca, Mg and P than control tissues. In soil, decreases in Ca, Mg, Fe, Na, K and P contents and increases in Al and S contents were noted.

328. BALLARD, T.M. Foliar analysis research. E.P. 889. IN: Forest Research Review 1981-82
Ministry of Forests, Victoria, B.C., 1983: 54
Subject Codes: N/A
RCA: X1064

Nitrogen, sulfur, iron, phosphorus, boron and potassium deficiencies were diagnosed from foliar analysis for the Prince George, Cariboo and Kamloops Forest Regions. Of these deficiencies, the last three appear least common and least serious. Studies were carried out to improve foliar sampling procedures and methods for total iron and copper analysis. Computer programs were developed or modified to make foliar analysis data files and diagnose nutrient status of spruce, Douglas-fir, western hemlock, western red cedar and lodgepole pine.

329. BENZIAN, B. Nutrition of young conifers and soil fumigation. IN: Root diseases and soil-borne pathogens, Symposium: 252 pp.
Univ. of California Press, Berkeley, Calif. USA, 1970: 222-225
Subject Codes: 2.3
BIO: 71030054

330. BIGG, W.L., DANIEL, T.W. Effects of nitrate, ammonium and pH on the growth of conifer seedlings and their production of nitrate reductase.
Plant and Soil, 1978, 50(2): 371-385
23 ref.
Subject Codes: 5.1, 7.8
CAB: 1032774

Seedlings of lodgepole pine (Pinus contorta), Engelmann spruce (Picea engelmannii) and Douglas-fir (Pseudotsuga menziesii), all of Utah provenance, were grown in tube cultures on sand or perlite irrigated with NO3, NH4 or NH4 + NO3 at pH 4.6, 5.3 or 6.0 (9 treatments). Growth (root and shoot dry weight, shoot wet weight) was poorest on NO3 for pine and spruce and on NH4 for Douglas-fir (which grew significantly more at pH 5.3). In a second experiment growth of Douglas-fir seedlings on plastic beads was relatively poor compared to the first experiment. Nitrate reductase (NR) activity decreased in the order NO3, NO3 + NH4, NH4, in both Douglas-fir and pine. The results are consistent with the preference of Douglas-fir (in Utah) for calcareous sites. It is noted that under field conditions conifer seedlings would probably be mycorrhizal, with fungal NR activity.

331. BINNS, W.O., MAYHEAD, G.J., MACKENZIE, J.M. Nutrient deficiencies of conifers in British forests. An illustrated guide.
Leaflet, Forestry Commission, UK, 1980, No. 76: 23 pp.
12 ref., 10 pl. (col.)
Language: en
Summary Languages: fr, de
Subject Codes: 3.7
CAB: 1270333

Symptoms of N, P and K deficiency in stands up to 5 m ht. are described and illustrated for Sitka spruce, Scots pine and lodgepole pine. Less complete coverage is given for Norway spruce, Corsican pine, Douglas-fir, western hemlock, Japanese larch (Larix kaempferi) (L. leptolepis) and hybrid larch (L. X eurolepis) as well as for the rare deficiencies of Mg and Cu. The foliar nutrient concn. associated with deficiency is tabulated for N, P, K and Mg in each species; also tabulated are site types where deficiencies in spruce and pine are most likely. Deficiency symptoms, when used in conjunction with foliar analysis, site study and local experience, can form a practical basis for prescribing fertilizer treatment. From authors' summary.

332. CANHAM, A.E., MCCAVISH, W.J. Some effects of carbon dioxide, day length and nutrition on the growth of young forest tree plants 1. In the seedling stage.
Forestry (OXF), 1981, 54(2): 169-182
Subject Codes: 5.1, 6.4
BIO: 73046246

The possibilities of accelerating seedling growth in 3 important forest tree species by increasing C02 concentration, day length and nutrition were examined. Doubling the frequency of application of a standard liquid feed increased plant

height by 8-10%, but extending the day length to 18 h had only a small initial effect which was not sustained. Increasing the C02 concentration significantly increased growth in both Sitka spruce (Picea sitchensis) and lodgepole pine (Pinus contorta) but similar increases with Corsican pine (Pinus nigra var. maritima) were not statistically significant. Under the conditions of the experiment the tree height normally achieved after 16 wk could be attained in 14-15 wk by increasing the C02 concentration 4-fold.

333. COUTTS, M.P., PHILIPSON, J.J. Mineral nutrition and tree root growth.
Acta. Hortic. (The Hague), 1980, 0(92): 123-136
Subject Codes: 2.3
BIO: 21041298

334. DALTON, D.A., ZOBEL, D.B. Ecological aspects of nitrogen fixation by Purshia tridentata.
Plant and Soil, 1977, 48(1): 57-80
47 ref.
Subject Codes: 2.3, 3.5
CAB: 856349

Acetylene reduction techniques were used to assay nodule activity in P. tridentata growing in the central Oregon pumice region (mainly in the understorey of Pinus ponderosa and also in P. contorta stands) and in the greenhouse. Max. rates were observed at 20 deg. C. Rates were much lower at 15 deg C (the summer soil temp.) and declined in water-stressed plants. Nodule activity began in May-June when soil temp. (at 20 cm depth) increased above 10 deg. C, reached a peak in June-July and declined sharply in late July as water stress increased to -25 bars. Nodule activity began later and was lower (until mid-July) in plants shaded by P. contorta. Only 46% of the plants examined were modulated. The estimated N accretion rate was only 0.057 kg/ha p.a. (0.005% of total soil N) and it is improbable that P. tridentata contributes significant amounts of N to the ecosystems at the sites studied. From authors' summary.

335. DIGHTON, J., HARRISON, A.F. Phosphorus nutrition of lodgepole pine and Sitka spruce stands as indicated by a root bioassay.
Forestry, 1983, Vol. 56, No. 1.
Subject Codes: N/A
RCA: X1110

336. DIGHTON, J., HARRISON, A.F., MASON, P.A. Is the mycorrhizal succession on trees related to nutrient uptake?
J. Sci. Food. Agric., 1981, 32(6): 629-630
Subject Codes: 2.3
BIO: 21064247

337. ETTER, H.M. Effect of nitrogen nutrition upon sugar content and dry weight of juvenile lodgepole pine and white spruce.
Can. J. For. Res., 1972, 2(4): 434-440
Subject Codes: N/A
BIO: 56014066

338. FORGEARD, F., GLOAGUEN, J.C., TOUFFET, J. Interception of precipitation and supply of minerals to the soil by rainfall and rain-water leachates in an Atlantic beach forest and in some coniferous stands in Brittany.
Annales des Sciences Forestieres, 1980, 37(1): 53-71
38 ref.
Language: fr
Summary Languages: en
Subject Codes: N/A
CAB: 1246999

Measurements were taken in 8 coniferous stands of different species and in a mature beech stand during 1973, 1974 and 1975. The interception study was continued in 1976 and 1977 in 7 development stages (from thicket to mature timber)

of the beech forest. Interception by conifers was greater than that of beech for the same b.a. per ha. The amount of interception by the beech was dependent on stand structure and age. The amount of interception by conifers varied seasonally, being lower in spring and summer, whereas for beech there was no relation to season; this is explained by seasonal differences in the type of rainfall cancelling out canopy differences in beech. Rainfall carried more Na in the winter; seasonal variations were not detected for other elements. Rainfall supplied 68 kg/ha of mineral elements annually. Throughfall had a greater concn. of minerals than rainfall, the concn. varying according to mineral elements and species. Annual mineral supply by throughfall was greater for beech forest (146 kg/ha) than for coniferous forest (87.5 - 138 kg/ha). Minerals in stemflow were 21 kg/ha for beech, 3.5 - 20 kg/ha for conifers.

339. KRAJINA, V.J. Ammonium nitrate in nitrogen economy of conifers in Douglas-fir forests of the Pacific Northwest of America.
Pac. Sci. Congr. Proc. 1, 1971: 44
Subject Codes: 7.8
BIO: 73016140

340. KRAJINA, V.J., MADOC-JONES, S., MELLOR, G. Ammonium and nitrate in the nitrogen economy of some conifers growing in Douglas-fir communities of the Pacific Northwest of America.
Soil Biol. Biochem., 1973, 5(1): 143-147
Subject Codes: N/A
BIO: 73029326

341. MILLER, H.G., WILLIAMS, B.L. Forest soils and tree nutrition. Macaulay Inst. for Soil Res., Aberdeen, Scotland, UK, 1976: 53-54
3 ref.
Subject Codes: 3.6
CAB: 796196

Nitrogen mineralization rates were studied in samples taken from peat planted with lodgepole pine (Pinus contorta) and from unplanted areas in the north of Scotland. CO2 evolution was greater from unplanted peat indicating a greater demand for N by a rapidly growing population of aerobic microorganisms, resulting in a lower net accumulation of mineral N. Samples from planted sites had less moisture, reduced pH values and lower Ca contents. Attempts to identify and characterize the organic N in peat continued with incubation studies on particle-size fractions isolated from peat by wet sieving. In relatively undecomposed Sphagnum peat (1% N in any of the fractions was mineralized despite a range of N content from 0.32% of oven-dry matter in coarse plant remains less than 5 mm to 1.36% in fine material less than 5 mu m. In well decomposed Molinia peat, N content of the same size fractions ranged from 1.16 to 2.87%; between 4.6 and 6.1% N in coarse fractions less than 1 mm and less than 2.4% in five fractions was mineralized.

342. WILL, G.M., YOUNGBERG, C.T. Some foliage nutrient levels in tree and brush species growing on pumice soils in central Oregon, USA.
Northwest Sci., 1979, 53(4): 274-276
Subject Codes: 2.7, 3.7
BIO: 71001815

Foliar analysis is becoming an important tool in evaluating soil fertility and site quality. During soil-vegetation studies on pumice soils in central Oregon, foliage samples from 6 tree species (Pinus ponderosa, P. contorta, P. monticola, Abies grandis, A. amabilis, Tsuga mertensiana) and 4 shrub species (Ceanothus velutinus, Arctostaphyloc patula, Costanopsis sempervirens, Purshia tridentata) were collected from 5 sites and analyzed for major and minor nutrient elements. There were marked differences in nutrient levels between species, but none were observed between sites. Tree foliage levels of the nutrients for which analyses were made indicated adequate supplies of everything but S.

343. WILLIAMS, B.L., COOPER, J.M., PYATT, D.G. Effects of afforestation with Pinus-contorta on nutrient content acidity and exchangeable cations in peat.
Forestry (OXF), 1978, 51(1): 29-36
Subject Codes: 3.6, 7.4.1
BIO: 66064561

Nutrient contents, acidity and exchangeable cations in the upper 300 mm of peat beneath lodgepole pine were compared with those in peat from contiguous unplanted areas at each of 6 sites. N, P and K contents, which are significantly higher in flushed blanket bog peat than in peat from either raised bog or unflushed blanket bog, are not significantly altered by the presence of trees. Ca and Mg contents, on the other hand, although similar in peat from different bog types, are lower in peat beneath the tree crop. Exchangeable Ca2+, Mg2+ and K+ are replaced by Na+ and H+ in planted peat but the increase in H+ content exceeds the loss of base cations, reflecting a higher number of exchange sites. This increase accounts for lower values of both base saturation and pH in planted peat and is attributed to enhanced decomposition promoted by aerobic conditions beneath the tree crop.

344. WILLIAMS, B.L., COOPER, J.M., PYATT, D.G. Some effects of afforestation with lodgepole pine pinus-contorta on rates of nitrogen mineralization in peat.
Foestry (OXF), 1979, 52(2): 151-160
Subject Codes: 3.3, 7.4.1
BIO: 69057531

Rates of mineral N production and C02 evolution in incubated samples from the upper 300 mm of peat beneath lodgepole pine (P. contorta Dougl.) were compared with those for adjacent unplanted areas at each of 6 sites in the North of Scotland (UK). Under both aerobic (moist) and anaerobic (waterlogged) conditions, rates of mineral N production at 30 degree C. are strongly influenced by peatland type, sampling depth and afforestation. During the early stages of the incubation under aerobic conditions, samples of planted peat showed a more rapid accumulation of mineral N than did samples from unplanted areas, the amounts after 17 days being 170 ppm and 46-ppm mineral N, respectively; after 62 days, however, the difference was no longer significant. The mean rate of C02 production averaged 446 .mu.g C02 g-1 day-1 in planted as against 728 .mu.g in unplanted peat. Under anaerobic conditions, amounts of mineral N accumulated were similar in planted and unplanted sites but a difference in accumulation between the 0-150 and 150-300 mm horizons in unplanted peat was significantly reduced beneath the trees.

## 3.4 SUCCESSION

345. ANON. Growth of lodgepole pine seedlings in competition with grass.
B.C. Ministry of Forests, 1979: Res. Memo No. 37
Summary Codes: N/A
RCA: X1152

346. ANTOS, J.A., HABECK, J.R. Successional development in abies-grandis forests in the Swan Valley, western Montana, USA.
Northwest Sci., 1981, 55(1): 26-39
Subject Codes: N/A
BIO: 73074622

A. grandis is abundant and potentially climax over a major part of the Swan Valley in western Montana. This area is among the easternmost extensions of wet, low elevation forests related to the Pacific maritime climatic influence. Species coverage and site parameters were ascertained on 56 natural stands representing a wide range of site conditions and stand ages. The stand data were analyzed using polar ordination techniques. Site moisture status and successional development are the most important factors determining species composition among the A. grandis forests studied. The natural landscape in the Swan Valley is composed of a mosaic of various-aged stands. Few, if any, stands have reached climax status due to the repeated occurrence of fire. After intense fires, Larix occidentalis and Pinus contorta become established. When stands over 150 yr old burn, L. occidentalis tends to predominate in the regeneration; if the stands are younger, P. contorta tends to be favoured. Pseudotsuga menziesii and Pinus monticola establish best during the 1st years of stand development and form an important component of many old stands. A. grandis typically forms a layer below the L. occidentalis or P. contorta canopy. Tree compositional changes along synthesized developmental pathways and understory alterations are discussed. This forest vegetation complex as a whole appears to have been stable under natural conditions; but on any given site, a wide range of communities occurred over time

as wildfires repeatedly recycled the vegetation through a variety of developmental sequences.

347. CLARK, M.B., MCLEAN, A. Growth of lodgepole pine seedlings in competition with grass.
Research Note, Ministry of Forests, British Columbia, 1979, No. 86: iii + 13 pp. 9 ref.
Subject Codes: 8.8.5
CAB: 1442784

The effects were studied of (a) 5 sowing densities of Dactylis glomerata, (b) various rates of sulphur and/or nitrogen application, (c) 6 different grass species, and (d) simulated grazing (clipping) on survival and growth of Pinus contorta var. latifolia seedlings in an experimental area in British Columbia. Pine survival was n.s.d. in relation to (a) or (c), but early ht. growth and total seedling wt. were significantly reduced at high rates of grass sowing (4.5 kg/ha or more). In (b) high rates of N gave high grass yields (which inhibited pine growth). Pine seedling survival and total biomass were n.s.d. in (d), but ht. was greater under clipping. To balance tree and grass productivity, it is recommended that N and S are applied at less than 50 kg/ha and that grazing should be restricted to the 1st half of the annual grazing season.

348. CLARK, M.B., MCLEAN, A. Grass, trees and cattle on clearcut-logged areas.
J. Range Manage., 1980, 33(3): 213-217
Subject Codes: 7.5, 8.5, 8.8.5
LISC: 655356

Generally, the presence of domestic grass had little effect on germination or survival of conifers on clearcut-logged areas, except where the stand of grass became overly dense. In cases where inhibiting effects were apparent, the competition from native vegetation was of as much consequence as the competition from domestic grasses. Results of the study suggest that where numbers of cattle and period of grazing were adequately controlled, damage to lodgepole pine and spruce seedlings were negligible. Damage was a result of repeated trampling rather than browsing. Poor cattle management in some situations resulted in overutilization of forage and large numbers of lodgepole pine seedlings were killed or damaged. However, the number was often insignificant in relation to the mortality of seedlings from natural causes.

349. CORNS, I.G.W. Early secondary plant succession after pulpwood clear cutting in the Loeer Foothills region of Alberta.
Am. J. Bot., 1971, 58(5 part 2): 481
Subject Codes: 8.4
BIO: 72007021

350. DAY, R.J. Stand structure succession and use of southern Alberta's Rocky Mountain forest.
Ecology, 1972, 53(3): 472-478
Subject Codes: 8.8
BIO: 55007199

351. DEITSCHMAN, G.H., PFISTER, R.D. Growth of released and unreleased young stands in the western white pine type.
US For. Serv. Research Paper INT-132, 1973: 1-3
Subject Codes: N/A
BIO: 73089701

352. DUNWIDDIE, P.W. Recent tree invasion of subalpine meadows in the Wind River Mountains, Wyoming.
Arctic and Alpine Research, 1977, 9(4): 393-399
15 ref.
Subject Codes: 6.6
CAB: 878372

A dendrochronological study was made of trees of Engelmann spruce (Picea engelmannii) lodgepole pine (Pinus contorta) and whitebark pine (Pinus albicaulis) invading a subalpine meadow in W. Wyoming. Invasion began in about 1890, but has advanced little since 1963. The trees' growth rate increased with increasing distance from the edge of the forest, the differences in growth rate being maintained as the trees aged. The results implied that invasion was limited by conditions limiting the initial establishment of trees, rather than their growth. It is suggested that the initial tree invasion was made possible by cattle grazing, which reduced competition from the meadow vegetation. The cessation of grazing in 1962 was probably responsible for the subsequent lack of tree establishment.

353. KUMLER, M.L. Plant succession on the sand dunes of the Oregon coast.
Ecology, 1969, 50(4): 695-704
Subject Codes: N/A
BIO: 51058753

354. LYON, L.J. Vegetal development on the Sleeping Child Burn in western Montana, 1961 to 1973.
USDA For. Serv. Res. Paper, Intermountain For. and Range Exp. Stn., 1976, No. INT-184: iv + 24 pp.
1 ref.
Subject Codes: 3.2, 3.6, 6.3, 7.1
CAB: 782684

In the year following the 1961 Sleeping Child forest fire in the Bitterroot Forest, Montana, 11 permanent transects were established within the burned area, and data were collected for tree density, shrub-crown volume, and % cover and frequency of occurrence of herbaceous and low woody species, over a 12-year period. Only 4 transects were considered indicative of seral forest succession independent of superimposed management activities including salvage logging, cattle grazing, and chemical thinning of tree seedlings. Mortality of tree seedlings (predominantly Pinus contorta) amounted to 48% of established plants during the study period; shrub-crown volumes exceeded 2000 ft3/acre, while cover at ground level reached nearly 60%. Vegetal cover due to aerially-sown, introduced grasses, was an important component of the plant communities for the first 6-8 years. No information is given about vegetation before the fire, but most of the area is classified as Abies lasiocarpa/Xerophyllum tenax habitat type.

355. MEHRINGER, P.J. Jr., ARNO, S.F., PETERSEN, K.L. Postglacial history of Lost Trail Pass, Bog Bitterroot Mountains, Montana, USA.
Arct. Alp. Res., 1977, 9(4): 345-368
Subject Codes: 3.0, 3.2, 3.6
BIO: 65066491

Studies of sediment, chronology, fossil pollen and charcoal from cores from Lost Train Pass B. (2 152 m) provide the 1st postglacial bog, forest and fire history for the Bitterroot Mountains (USA). The 6.27 m of sediment, dated by 16 radiocarbon dates and 2 volcanic ashes, represent lake, fen and bog deposition spanning the last 12,000 yr. Lycopodium spores were introduced as tracers into the 81 constant-volume samples to estimate pollen and charcoal influx. Because of considerable variation between samples, pollen and charcoal estimates were averaged by pollen zones. Glacial ice withdrew, leaving a lake 12,000 yr ago. Sagebrush steppe dominated the landscape for the next 400 - 500 yr. If lodgepole and whitebark pine are the diploxylon and haploxylon pine pollen in the record, then by 11,500 yr. ago whitebark pine forests replaced the steppe and persisted for the next 3000-4000 yr under climatic conditions that were probably cooler than present. Two falls of Glacier Peak volcanic ash, separated by less than 25 yr., occurred about 11,250 BP. By 7000 yr. ago, under warmer but not necessarily drier climatic conditions, Douglas-fir and lodgepole pine replaced whitebark pine and charcoal influx increased. The fall of Mazama volcanic ash was dated at about 6700 yr ago. By 5000 yr ago aquatic, fen and bog microfossils became important. With the return to cooler climates, about 4000 yr ago, Douglas-fir was no longer common in the pine forest. Little vegetational change is indicated after 4000 yr ago. However, more charcoal was deposited during the last 2000 yr than during the previous 9500 yr.

356. PATTEN, D.T. Succession from sagebrush to mixed conifer forest in northern Rocky Mountains, USA, Artemisia-tridentata Pinus-contorta.

Amer. Midland Natur., 1969, 82(1): 229-240
Subject Codes: N/A
BIO: 50124137

357. PERRY, D.A. Minimization of intraspecific competition through differential growth pattern in tree species. IN: Proceedings of the Eighth World Forestry Congress, Jakarta, 16-28 Oct., 1978.
Sch. For. Oregon State Univ., Corvallis, OR, USA, 1978, No. FID-I/17-2: ii + 6 pp.
7 ref.
Subject Codes: 1.4, 5.4
CAB: 1191655

Results from a study of the early growth of 10 wind-pollinated lodgepole pine families from 5 Rocky Mountain populations, in which bud set and bud burst (in all 5 populations) and ht. growth from the first to fifth years (in 4 out of 5 populations) were negatively correlated with site index, suggest that variation in early growth pattern may be an adaptive strategy to minimize intraspecific competition for scarce resources.

358. PFISTER, R.D., DAUBENMIRE, R. Ecology of lodgepole pine Pinus contorta Dougl. IN: Management of Lodgepole Pine Ecosystems. USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 27-46
38 ref.
Subject Codes: N/A
CAB: 757519

Pinus contorta grows in a wide variety of environments and displays several successional roles. This paper briefly describes its taxonomy, autecology, ecological amplitude, and successional role in relation to the environment.

359. ROMME, W.H., KNIGHT, D.H. Fire frequency and subalpine forest succession along a topographic gradient in Wyoming.
Ecology, 1981, 62(2): 319-326
Subject Codes: 3.2, 3.6
LISC: 634786

Differences in fire frequency and the rate of secondary succession following fire have had a major effect on the present composition of forest vegetation in a 4 500-ha undisturbed watershed in the subalpine zone of the Medicine Bow Mountains, southeastern Wyoming, USA. Periodic fire coupled with slow secondary succession has perpetuated lodgepole pine forest on the upland, while mature Engelmann spruce- subalpine fir forests have developed in sheltered ravines and valley bottoms where fire is less frequent and succession following fire is more rapid and/or more direct. A graphic model is presented showing the relationship between topographic position, fire- free interval, and the occurrence of mature forest dominated by spruce and fir.

360. UGOLINI, F.C., MANN, D.H. Biopedological origin of peatlands in south east Alaska.
Nature, UK, 1979, 281,5730: 366-368
11 ref.
Subject Codes: 3.6
CAB: 1146795

Peatlands are the final stage in plant succession on level surfaces in this region, where continuing coastal uplift enables younger and older surfaces to be compared. The succession of soils and vegetation was studied near Lituya Bay on transects from sea shore to peatland across 3 marine terraces of increasing age. Sitka spruce on the lower terraces was followed by mixed forest of spruce, western hemlock, etc. which eventually degenerated into peat bog with occasional lodgepole pine. Podzolization of the soil is accompanied by development of an iron-cemented pan that impedes drainage leading to deterioration in forest growth, accumulation of an organic horizon and invasion by Sphagnum.

361. VALE, T.R. Tree invasion of Cinnabar Park in Wyoming, USA.

Am. Midl. Nat., 1978, 100(2): 277-284
Subject Codes: N/A
BIO: 67053368

A recently published analysis of soil samples from Cinnabar Park in the Medicine Bow Mountains of Wyoming (USA) suggested that the meadow is migrating. The age structure and other characteristics of the adjacent forest vegetation evaluated support the view that 1 side of the park has been invaded by trees (lodgepole pine, Pinus contorta) over the last century, but provide no evidence to suggest that the other side of the meadow is advancing into the forest. The earlier interpretation of the park as a migrating unit is replaced with the view that the park is closing through tree invasion on 1 side.

362. VALE, T.R. Tree invasion of montane meadows in Oregon, USA.
Am. Midl. Nat., 1981, 105(1): 61-69
Subject Codes: 3.2
BIO: 71079735

Mesic montane meadows (Rubus parviflorus/Pteridium aquilinum and Bromus carinatus/Rudbeckia occidentalis assocations) in the Cascade Mountains of central and southern Oregon were invaded recently by trees (Libocedrus decurrens, Abies concolor, A. magnifica, A. grandis, A. procera, A. amabilis, Pinus monticola, P. contorta, Tsuga mertensiana, T. heterophylla and Pseudotsuga menziesii) from the adjacent forests. Cessation of sheep grazing coincides with the initiation of the tree invasions, but the absence of frequent fires and cool moist weather may have contributed to the conditions which favored the unstable ecozones.

363. WHIPPLE, S.A., DIX, R.L. Age structure and successional dynamics of a Colorado subalpine forest.
Am. Midl. Nat., 1979, 101(1): 142-158
Subject Codes: N/A
LISC: 302021

Population age structures of old-growth Engelmann spruce (Picea engelmannii), subalpine fir (Abies lasiocarpa) and lodgepole pine (Pinus contorta) are described in the Colorado Front Range subalpine forest (2850 and 3500 m). Five types of age structures can be recognized; up to 4 different types of age structures were found in one species under different environmental or historical conditions and no species showed the same type of age structure throughout its entire range of occurrence. Age structures are used to infer their climax or successional (self-replacing or not self-replacing) status. Three types of forest are recognized: (1) climax lodgepole; (2) climax spruce-fir, which is pioneered after disturbance by lodgepole; and (3) climax spruce-fir which is pioneered primarily by spruce. The changes from one forest type to another follow a unidimensional gradient which begins with climax lodgepole at low elevation, dry sites, followed by a forest mosaic of successional lodgepole and climax spruce-fir at both higher elevations and intermediate moisture sites, and ends with climax spruce-fir in which lodgepole is not pioneer, at both high elevations and on the most mesic sites.

## 3.5 FLORISTICS

364. BASILE, J.V. Forage productivity in the lodgepole pine type. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 246-263
46 ref.
Subject Codes: 3.4
CAB: 757623

Another version of work already noticed on understory production in the Pinus contorta forest type.

365. DORWORTH, C.E. Gremmeniella-abietina collected in Alberta, Canada.
Plant Dis. Rep., 1975, 59(3): 272-273
Subject Codes: N/A
BIO: 60027705

366. HILL, M.D., HAYS, J.A. Ground flora and relative illumination under differing crop species in a Forestry Commission experiment in North Wales.
CST Report, Natural Conservancy Council, UK, 1978, No. 171: 26 pp.
Subject Codes: 2.2, 3.6
CAB: 1329617

367. JACKSON, M.T., FALLER, A. Structural analysis and dynamics of the plant communities of Wizard Island - Crater Lake National Park.
Ecol. Monogr., 1973, 43(4): 441-461
Subject Codes: N/A
BIO: 57036499

## 3.6 HABITATS

368. BROWN, J.K. Fire cycles and community dynamics in lodgepole Pine forests. IN: Management of Lodgepole Pine Ecosystems, Symposium Proceedings.
USDA For. Svc., Ogden, Utah, USA, 1975: 430-457
Subject Codes: 3.2, 3.4, 4.4
CAB: 710417

This paper examines the influences of fire on succession, community diversity and stability, serotinous phenology, stand establishment and structure, and fuel accumulation. Complex interactions affecting fire potential are discussed.

369. CACEK, T.L. An ecological interpretation of north central Colorado.
Dissertation Abstracts International, B, 1975, 35(7): 3282-3283
Subject Codes: 1.5, 3.1
CAB: 556431

Briefly describes the general principles of geology, ecology and climatology with reference to Colorado. The main part of the work describes the geology, climatology and ecology of four sites with different plant communities: Pawnee Buttes (short-grass prairies), Horsetooth State Recreation Area (mixed grass prairie, Mountain Mahogany shrubland and ponderosa pine forest); Rocky Mountain National Park (ponderosa pine forest, spruce/fir forest, krummholz, alpine tundra, perpetual ice and snow, lodgepole pine forest and quaking aspen forest); and the Colorado State University Nature Center (cottonwood bottomland).

370. CAREY, M.L., O'CARROLL, N. Potassium accretion by Pinus-contorta on oligotrophic peat in the west of Ireland.
Plant Soil 1981, 60(3): 471-476
Subject Codes: 3.3
BIO: 75010176

A 22-yr-old crop of P. contorta on oligotrophic peat contained 85 kg ha-1 more K than adjacent unplanted areas. The forest cover aids in conserving rainfill-derived K which in the natural (unplanted) state is lost to drainage.

371. CORNS, I.G.W., LA ROI, G.H. A comparison of mature with recently clear-cut and scarified lodgepole pine forests in the Lower Foothills of Alberta.
Canadian Journal of Forest Research, 1976, 6(1): 20-32
31 ref.
Language: en
Summary Languages: fr
Subject Codes: 3.4, 3.5, 7.1
CAB: 782701

The vegetation was studied in mature stands of Pinus contorta var. latifolia and

on naturally regenerated areas that had been clear-felled 6-12 years before the study. The undisturbed stands had weak shrub strata, well-developed herb/dwarf shrub strata and continuous feather moss strata. In the clear-felled stands the cover of tree regeneration was 5%, with Pinus contorta and Populus tremuloides as condominants. Shrub cover was 5%, herb/dwarf shrub cover as 44%, dominated by 9 species of the mature forest; and bryoid cover was 13%. The density and above-ground biomass of the young trees increased rapidly during the sampled age interval. The distribution and abundance of several important species in the clear-felled area were correlated with soil moisture on 2 sampling dates in summer. The clear-felled community was richer in vascular species and had a more even distribution of cover among species than the mature stands. From authors' summary.

372. DYRNESS, C.T. Effect of wildfire on soil wettability in the High Cascades of Oregon.
USDA For. Serv. Res. Paper, Pacific NW For. and Range Exp. Stn., 1976, No. PNW-202: 18 pp.
16 ref.
Subject Codes: 6.3
CAB: 843400

Soil wettability and trends in recovery of vegetation were studied for 6 years after a major fire in 1967 that affected 7700 acres of Pinus contorta forest at ca. 5000 ft. alt. Wettability of the sandy soils was evaluated by determinations of the liquid/solid contact angle and the infiltration rate. Burning apparently increased the water repellency of the soil at depth of 1-9 inches, and this effect persisted for 5 years; infiltration rates during the third and fourth years recovered more rapidly on lightly than on heavily burned soils. Recovery of vegetation occurred much more rapidly in lightly than in heavily burned areas. Most plant species that became established after the fire were present before the fire. Grasses and clover, sown from the air soon after the fire, contributed only negligible amounts of cover.

373. FARRELL, E.P., MULLEN, G.J. Relationship between peat depth and growth rate of forest trees.
Forest Ecology and Management, 1978, 1(4): 335-338
5 ref.
Subject Codes: 3.1, 5.1, 5.2
CAB: 1161024

Studies in young stands of Sitka spruce and lodgepole pine, apparently free from N or P deficiency, growing on blanket peatland in western Ireland, showed that ht. and diam. increment were positively correlated with depth of peat.

374. GOLDIN, A., NIMLOS, T.J. Vegetation patterns on limestone and acid parent materials in the Garnet Mountains of western Montana.
Northwest Science, 1977, 51(3): 149-160
18 ref.
Subject Codes: N/A
CAB: 878379

Topographic characteristics (aspect, elevation, slope) soil type and canopy cover of tree and undergrowth vegetation were recorded in 45 plots on sites derived from (a) limestone, (b) granite and (c) quartzite parent materials. A total of 8 habitat types were present in the study area ( the NW sector at 1525-1975 m alt.) Plant communities in (a) and (b) had no habitat types in common, (a) supporting dry habitat types with open stands of Pseudotsuga mensisii and many forbs, and (b) moist habitat types dominated by Pinus contorta (with Abies lasiocarpa) and shrubs. In (c), 7 habitat types were present on sites ranging from relatively xeric to relatively mesic and resembling those in (a) and (b) resp. Ordination of plots by species coverage class confirmed the site relationships. Species diversity of vegetation was greatest in (a) and least in (b), while total canopy cover was greatest in (b). Results suggest that the characteristic limestone vegetation is primarily determined by soil dryness.

375. HO, I. Acid phosphatase activity in forest soil.
Forest Science, 1979, 25(4): 567-568
8 ref.

Subject Codes: N/A
CAB: 1213293

Soil samples were taken in Oct. 1976 from 7 stands in Oregon. Acid phosphatase activity was significantly higher in red alder (Alnus rubra) and red alder/Douglas-fir stands than in the pure stands of Douglas-fir, ponderosa and lodgepole pines, and western juniper (Juniperus occidentalis), or pasture.

376. KRUCKEBERG, A.R. Plant life on serpentinite and other ferromagnesian rocks in northwestern North America.
Syesis, 1969, 2(1-2): 15-114
Subject Codes: N/A
BIO: 51105380

377. LAINE, J. Initial development of Pinus contorta on a nutrient-poor open bog in Finland.
Suo, 1979, 30(2): 27-32
10 ref.
Language: fi
Summary Languages: en
Subject Codes: 3.3, 3.7
CAB: 1244842

Preliminary results of experiments on the initial development of lodgepole pine (P. contorta var. latifolia) (favourable provenance, origin Canada) compared with that of Scots pine (P. sylvestris) on a drained small-sedge bog nine years after planting (in 1969) are described. The height development of Pinus contorta clearly exceeded that of P. sylvestris, except in one area with apparently better nutrient status. The mortality of lodgepole pine was significantly lower than that of Scots pine in all areas. The requirements of lodgepole pine for drainage and nutrients therefore appear to be lower than those of Scots pine.

378. LEES, J.C. Soil aeration response to draining intensity in basin peat.
Forestry (OXF), 1972, 45(2): 135-142
Subject Codes: N/A
BIO: 55052214

379. MCLEOD, A.J., RAPP, E. Optimal sites for conifers in the boreal forest region of Alberta.
Can. Agric. Eng., 1978, 20(2): 77-80
Subject Codes: N/A
LISC: 263303

The study reported in this paper deals with the effects of soil moisture, soil texture and vegetative competition on survival and growth of four coniferous species common to the Boreal Forest Region of Alberta. Tree seedlings were planted in soil boxes, two of sandy loam and two of silty clay soil. Each soil box was split into five zones running perpendicular to the moisture gradient which ranged from poorly to rapidly drained. Measurements were made and data analyzed for species survival, height growth, diameter growth and total root length. Based on survival and height growth, tamarack preferred an imperfectly drained, nonvegetated silty clay soil while lodgepole pine preferred a non-vegetated sandy loam soil with no apparent moisture preference. Black spruce preferred a poorly to imperfectly drained, non-vegetated silty clay soil while white spruce preferred an imperfectly to moderately well-drained, non-vegetated silty clay soil.

380. MOIR, W.H., GRIER, H. Weight and nitrogen phosphorus potassium and calcium content of forest floor humus of lodgepole pine stands in Colorado.
Soil Sci. Soc., Amer. Proc., 1969, 33(1): 137-140
Subject Codes: 3.3
BIO: 51109796

381. NEILAND, B.J. The forest bog complex of southeast Alaska.
Vegetation, 1971, 22(1-3): 1-64

Subject Codes: 3.5
BIO: 54013247

382. PYATT, D.G., CRAVEN, M.M. Soil changes under even-aged plantations. IN: The Ecology of Even-aged Forest Plantations. Proceedings of Div. I., International Union of Forestry Research Organizations, Edinburgh, September, 1978. Cambridge, UK, Institute of Terrestrial Ecology, 1979: 369-386
29 ref.
Language: en
Summary Languages: fr, de
Subject Codes: N/A
CAB: 1175376

A review of the effects of afforestation and stand development in the soil moisture regime and aeration of upland sites in the UK, dealing in turn with iron-pan, gley and deep peat soils. Data are presented on the annual moisture characteristics of unplanted sites and sites planted with Sitka spruce, Norway spruce and lodgepole pine in Scotland. The need for site preparation to break the iron pan is discussed.

383. REED, R.M. Coniferous forest habitat types of the Wind River Mountains, Wyoming. American Midland Naturalist, 1976, 95(1): 159-173
29 ref.
Subject Codes: 3.2, 3.5
CAB: 662679

A further account of work already noticed from a thesis. From a study of 69 stands of relatively undisturbed vegetation, data are given on stand structure, undergrowth species, soils and topography. Five further vegetation types were recognized, dominated respectively by Pseudotsuga menziesii (on steep N-facing slopes between 2200 and 2600 m alt. with soil pH 6.6), Abies lasiocarpa (below 2600 m, soil pH 5.5, with codominant Picea engelmanii or Pinus contorta), Pinus contorta (between 2400 and 2900 m in the southern part of the area, soil pH 5.5), Picea engelmannii (above 2900 m, generally on burned areas, soil pH 5.0) and Pinus albicaulis (above 2900 m on exposed sites near the treeline, soil pH 5.1, with codominant Pinus flexilis).

384. ROMME, W.H., KNIGHT, D.H. Vegetation of a pristine Rocky Mountain watershed in relation to environmental gradients and fire.
N.M. Acad. Sci. Bull., 1978, 18(1): 13 pp.
Subject Codes: N/A
BIO: 16010125

385. VESTER, G., CRAWFORD, R.M.M. Different provenances of Pinus-contorta and their responses to inundated soil conditions classification based on morphological and metabolic criteria.
Flora (Jena), 1978, 167(5): 433-444
Language: de
Subject Codes: N/A
BIO: 68072643

The species P. contorta is classified as a flood-tolerant species by means of shoot growth measurements during a prolonged flooding experiment. Shoot growth data and mortality rates during experimental flooding as well as the root/shoot ratios of unflooded trees of different provenances reveal distinct ecotypes in flooding tolerance within the species P. contorta. A simple test on the flooding tolerance of these ecotypes is proposed. It is possible to predict the behaviour of different ecotypes during a flooding stress by means of weighing shoots and roots of unflooded trees. Changes in the sugar content in roots, caused by flooding, are examined in different provenances of P. contorta. The data obtained indicate a further metabolic distinction between flood-intolerant and flood-tolerant ecotypes.

386. WIDDEN, P., PARKINSON, D. The effects of a forest fire on soil micro fungi.
Soil Biol. Biochem., 1975, 7(2): 125-138
Subject Codes: 3.2

BIO: 60011411

387. WIKEN, E.B., BROERSMA, K., LAVKULICH, L.M., FARSTAD, L. Biosynthetic alteration in a British Columbia soil by ants (Formica fusca Linne).
Soil Science Society of America Journal, 1976, 40(3): 422-426
21 ref.
Subject Codes: N/A
CAB: 662568

The occurrence and pedological effects of active and disused ant mounds were studied by comparison with apparently unaffected soils in an area of Pinus contorta/grass vegetation in the sub-alpine region of Mt. Tatlow, Canada. The alterations by the ants tended to retard or alter the normal processes of leaching and horizon formation, but on desertion of the colonies, soils reverted to a steady state and resembled the surrounding soils.

388. WOODARD, P.M., MARTIN, R.E. Duff weight and depth in a high elevation Pinus contorta Dougl. forest.
Can. J. For. Res., 1980, 10(1): 7-9
Language: en
Summary Languages: fr
Subject Codes: 6.3
LISC: 493253

Variation in duff depth and weight was studied on 2 adjacent different aged subalpine stands in eastern Washington, USA. In a 105-year old P. contorta stand, the duff depth averaged 5.46 cm as compared with 4.57 cm for a 305-year old stand of the same habitat type. The difference between the means was not significant. The greatest duff depth (46 cm) in the younger stand was almost twice that of the older stand (26 cm), due principally to the time since last disturbance by fire. A correlation of duff depth (D:cm) to weight (W:tonnes per ha) produced the equations W = 7.26 + 13.270 which had r2=0.849 and SE = 7.06.

## 3.7 SITE

389. ALEMDAG, I.S. Metric site-index curves for white spruce and lodgepole pine in the upper Liard River area, Yukon Territory.
Info. Report, Forest Management Institute, Canada, 1976, No. FMR-X-33M: iii + 18 pp.
2 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 724298

390. BASILE, J.V. Site index for lodgepole pine - a poor indicator of site productivity for herbaceous plants.
US For. Serv. Research Note INT-152, 1971: 1-3
Subject Codes: 3.5
BIO: 72055210

391. BRICKELL, J.E. Equations and computer sub-routines for estimating site quality of 8 Rocky Mountain species.
US Forest Serv. Research Paper, INT-75, 1970: 1-22
Subject Codes: N/A
BIO: 52001939

392. BRICKELL, J.E. Estimating site quality in lodgepole pine stands. IN: Management

of Lodgepole Pine stands.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 154-185
39 ref.
Subject Codes: N/A
CAB: 757709

The development of site index curves for Pinus contorta is outlined. Application in the field is described and tables presented for curves that take into account the density of a stand (crown competition factor). A curve is given relating yield capability in terms of m.a.i. to site index. The estimation of site quality from vegetative or environmental factors is discussed.

393. DUFFY, P.J.B. Relationships between site factors and growth of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in the Foothills Section of Alberta.
Forest Research Branch, Department of Forestry Publication No. 1065, 1964: 60 pp.
44 ref.
Languages: en
Summary Languages: fr
Subject Codes: 5.0
RCA: X1073

A study was made of forest land productivity between the Red Deer and Brazeau Rivers in the Foothills Section of Alberta to facilitate prediction of yields for lodgepole pine. A preliminary site classification was developed on the finding that pine growth differs between parent materials. Correlations between site, stand factors, and pine growth were used to construct prediction equations for the site expressions - dominant height, average height, and basal area, total volume, and merchantable volume per acre. Prediction equations for pine and other species on other soils could be calculated using the survey and techniques outlined.

394. EIS, S., CRAIGDALLIE, D., SIMMONS, C. Growth of lodgepole pine and white spruce in the central interior of British Columbia.
Canadian Journal of Forest Research, 1982, Vol. 12(3): 567-575
12 ref.
Subject Codes: 5.1, 5.2
RCA: X1098

Height, diameter, volume growth, crown width, and stocking of lodgepole pine (Pinus contorta Dougl.) and white spruce (Picea glauca (Moench) Voss) were studied on the three most common forest sites in the central interior of British Columbia, to estimate their potential growth and their suitability for pure or mixed stands in managed second- growth forests established by planting. Spruce only should be planted on moist to wet alluvium sites; both species appear to be equally suitable on moist Aralia sites, and pine only should be planted on dry to moist Cornus-Moss sites. In mixed forests, suppressed spruce will have little volume at the time of pine harvest. In general, managed, fully stocked second-growth forests should produce greater volume per hectare than the present natural, unmanaged forests.

395. ILLINGWORTH, K. A preliminary ecological classification of lodgepole pine sites in the south-central interior of British Columbia.
Thesis, 1958
Subject Codes: N/A
RCA: X1005

396. ILLINGWORTH, K., ARLIDGE, J.W.C. Interim report on some forest site types in lodgepole pine and spruce-alpine fir stands.
Brit. Columbia Forest Serv. Res. Note 35, 1960: 44 pp.
Subject Codes: N/A
RCA: X1041

397. KIRBY, C.L. Site index equations for lodgepole pine and white spruce in Alberta.
Info. Rep., Northern For. Res. Centre, Canada, 1975, No. NOR-X-142: 12 pp.

10 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 699412

Presents site index (defined as the mean total height of dominant and codominant trees at a selected index of age of 70 years - taken as the number of growth rings at 1 ft above the ground) equations and curves for Picea glauca and Pinus contorta var. latifolia. The equations are based on data from the stem analysis of 243 P. glauca and 96 P. c. latifolia trees from well stocked stands in the commerical forest zone of Alberta.

398. MOGREN, E.W., DOLPH, K.P. Prediction of site index of lodgepole pine from selected environmental factors.
For. Sci., 18(4), 1972: 314-316
Subject Codes: N/A
BIO: 55048647

399. NOKOE, S., KOZAK, A. Obtaining a composite volume age function with the Gompertz model.
Northwest Sci., 53(1), 1979: 12-17
Subject Codes: 5.1
BIO: 18013560

400. PLUTH, D.J. Forest land classification and lodgepole pine productivity prediction.
Agriculture and Forestry Bull., Mar. 1983, Vol. 6, Number 1: 34-35
Subject Codes: N/A
RCA: X1111

An ecological land classification which is developed upon relationships among components of an ecosystem has greatest predictive value in forest management application. A multivariate approach to identification of site factors influencing productivity of lodgepole pine in west-central Alberta suggests that vegetation variables can contribute to the prediction of MATVI and SI.

401. SMITHERS, L.A. Assessment of site productivity in dense lodgepole pine stands.
Canada, Dept. N.A. and N.R. For. Br., For. Res. Div., Tech. Note No. 30, 1956: 20 pp.
Subject Codes: N/A
RCA: X1034

402. YOUNGBERG, C.T., DAHMS, W.G. Productivity indices for lodgepole pine on pumice soils.
J. Forest., 68(2), 1970: 90-94
Subject Codes: N/A
BIO: 51069324

## 4.0 REPRODUCTIVE BEHAVIOUR

403. EIS, S., CRAIGDALLIE, D. Reproduction of conifers. A (loose-leaf) handbook for cone crops assessment.
Report, Pac. For. Res. Ctre., Canada, 1971, BC-X-219: 24 pp.
8 pl. (col.)
Subject Codes: N/A
CAB: 1556344

404. OWENS, J.N. Sexual reproduction in Pinus contorta. E.P. 830 IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 5
Subject Codes: N/A
RCA: X1042

405. OWENS, J.N., SIMPSON, S.J., MOLDER, M. Sexual reproduction of Pinus-contorta 1. Pollen development: the pollination mechanism and early ovule development of lodgepole pine.
Can. J. Bot., 1981, 59(10): 1828-1843
Subject Codes: N/A
BIO: 7309733

406. OWENS, J.N., MOLDER, M. 1984. The reproductive cycle of lodgepole pine.
Ministry of Forests. Victoria, B.C. 29p.

### 4.1 SEED PRODUCTION AND DISPERSAL

407. BARTRAM, V.C. Sweden initiates a large scale tree improvement and seed production program for lodgepole pine (using Canadian provenances).
Forestry Chronicle, 1980, 56(2): 63-66
6 ref.
Language: en
Summary Languages: fr
Subject Codes: 1.4, 5.4
CAB: 1487284

408. CREMER, K.W. Speeds of falling and dispersal of seed of Pinus-radiata and Pinus-contorta.
Aust. For. Res., 1971, 5(3): 29-32
Subject Codes: N/A
BIO: 53066320

409. CROSSLEY, D.I. The production and dispersal of lodgepole pine seed.
Can. Dep. North. Aff. and Nat. Resour., For Br., For. Res. Div., Tech. Note 25, Ottawa, Ont. 1955: 12 pp.
Subject Codes: N/A
RCA: X1017

410. CROSSLEY, D.I. Effect of crown cover and slash density on the release of seed from slashborne lodgepole pine cones.
Can. Dep. North. Aff. and Nat. Resour., For Br., For Res. Div., Tech Note 41, Ottawa, Ont. 1956: 51 pp.
Subject Codes: 2.2
RCA: X1018

411. DAHMS, W.G., BARRETT, J.W. Seed production of central Oregon ponderosa and lodgepole pines.
USDA For. Serv. Res. Paper, Pacific NW For. and Range Exp. Stn., 1975, No. PNW-191: 13 pp.
18 ref.
Subject Codes: N/A
CAB: 556480

Reports results of studies since 1953 of seedfall, seed dispersal and seed germination % in Pinus contorta and Pinus ponderosa. Good seed-crops (150 000 sound seeds/acre) occurred in 12 out of 16 years for P. contorta and in 5 out of 22 years in P. ponderosa.

412. GULLBERG, U. Seed production of lodgepole pine for Sweden. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 263-273
20 ref.
Subject Codes: N/A
RCA: X1091

Discusses Sweden's long-term demand for Pinus contorta Dougl. var. latifolia seed from British Columbia and outlines plans for self-sufficient seed production in Sweden.

413. HUBER, R.F. (Compiler), POLLARD, D.F.W., EDWARDS, D.G.W., et al. High-quality collection and production of conifer seed. Proceedings of a workshop held November 14, 1979 in Edmonton, Alberta.
Information Rep., Northern For. Res. Centre, 1981, No. NOR-X-235: iii + 88 pp.
many ref., 12 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1526924

Eight papers are presented, mainly with reference to Manitoba, Alberta and Saskatchewan: Pollard, D.F.W. Genetic quality of seed source: variation, improvement and certification. 3-11 (12 ref.) Edwards, D.G.W. Cone collection and processing - effects on seed quality and yield 12-37 (17 ref., 11 pl.) Hellum, A.K. Lodgepole pine seed extraction. 38-53 (25 ref.) Cerezke, H.F. Effects of insects on seed and cone production. 54-61 (37 ref.) Leadem, C.L. Quick methods for determining seed quality in tree seeds. 64-72 (17 ref., 1 pl.) Wang. B.S.P. Measuring quality of tree seed. 73-78 (9 ref.) Edwards, D.G.W. Impact of seed quality on costs of nursery stock. 79-83 (5 ref.)

414. JONDELIUS, B. Demand for seed and planting stock for the next few decades.
Sveriges Skogsvardsforbunds Tidskrift, 1980, 78(1/2): 14-17
4 ref.
Language: sv
Summary Languages: en
Subject Codes: 7.3
CAB: 1407084

It is suggested that to meet the estimated minimum demand for 7 000 kg seed per year, about 1 000 ha Scots pine, Norway spruce and lodgepole pine seed orchards should be established in Sweden during the next decade; a change in emphasis from bare-rooted to container-grown planting stock would help.

415. JONSSON, S. How can the supply of Pinus contorta seed be safeguarded?
Sveriges Skogsvardsforbunds Tidskrift, 1980, 78(1/2): 96-103
1 ref.
Language: sv
Summary Languages: en
Subject Codes: 5.4
CAB: 1407095

A program for breeding P. contorta in Sweden, financed jointly by the Swedish Forest Service, County Forestry Boards and several private companies, involves the establishment of 6 seedling seed orchards (7-19 ha each) in S. and central Sweden. These orchards, due to be completed by 1985, will contain progenies of selected trees from Yukon, British Columbia and Alberta, Canada, and the first seed crops are expected about 1995.

416. PERRY, D.A. An estimate of the effective range of pollen dispersal in lodgepole pine Pinus-contorta.
Ann. Bot. (Lond.), 1978, 42(180): 1001-1002
Subject Codes: 1.5, 2.9, 5.4
BIO: 67022075

Introgression of jack pine genes into lodgepole pine territory, coupled with an estimate of how long the 2 spp. have been in contact, can be used to derive a rough value of average effective range of pollen dispersal. Transfer of jack pine genes to Montana (USA) in 3000 yr requires an average effective dispersal of 300 m/yr and 500 m/yr to Colorado, suggesting that dispersal distances are generally relatively modest.

417. PERSSON, A., LINES, R. (Chairman) Session VII: Seed production. IN: Proceedings of the IUFRO Working Party Mtg. 1980 on Pinus contorta Provenances in Norway and Sweden.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1980, No. 30: 263-343
many ref.
Subject Codes: 1.4, 5.4
CAB: 1358136

Hagner, M. Geographical variation in seed quality of lodgepole pine (Pinus contorta Dougl.) in western N. America. Kamra, S.K. Studies on Pinus contorta seed germinated at different temperatures. Nilsson, J.E., Eriksson, G., Rudin, D. Studies on flowering biology in 14 provenances on Pinus contorta in a Swedish field trial. Pollard, D.F.W. Certification and source data for Pinus contorta seed exported from Canada. Rosvall, O. The Swedish Pinus contorta tree improvement and seed production program.

418. ROSVALL, O. The Swedish Pinus contorta tree improvement and seed production program. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 329-343
6 ref.
Subject Codes: 1.4, 5.4
RCA: X1096

The future demand for Pinus contorta high quality seed will be met by seed production within Sweden. For each of six different seed zones in northern Sweden a seedling seed orchard will be established, based on parent trees selected from six corresponding regions in Canada. The parent tree selection, genetic testing, and seed production are described in this paper.

419. SMITH, C.C., BALDA, R.P. Competition among insects, birds and mammals for conifer seeds.
American Zoologist, 1979, 19(4): 1065-1083
83 ref.
Subject Codes: 6.1, 6.2, 6.6
CAB: 1272861

It is known that species of at least 5 orders of insects, 6 families of birds and 2 orders of mammals, in various combinations, can exploit the cones and seeds of most species of conifers in western North America. Lodgepole pine (Pinus contorta) is the exception to this pattern of broad taxonomic diversity of seed predators, in that only pine squirrels and coreid bugs attack its serotinous cones. The contrast between lodgepole pine and other conifers demonstrates that large intrinsic variation in the abundance of a resource fosters the evolution of a broad range of taxonomic groups to exploit the resource. The diverse groups are limited by different predators and alternate resources when conifer seeds independently decrease in abundance. The genera of trees exploited, the method of conifer exploitation and method of escaping starvation during cone-crop failure are tabulated for each of the animal groups mentioned, including the Coleoptera,

Hemiptera, Diptera, Hymenoptera and Lepidoptera.

420. WEBBER, J.E. Supplemental pollination in lodgepole pine seed orchard at RedRock, 1980. E.P. 821.03. IN: Forest Research Review 1981-82. Ministry of Forests, Victoria, B.C., 1983: 11-12
Subject Codes: N/A
RCA: X1043

## 4.2 SEEDBED PREFERENCE

421. DANIEL, T.W., SCHMIDT, J. Lethal and nonlethal effects of the organic horizons of forested soils on the germination of seeds from several associated conifer species of the Rocky Mountains.
Can. J. For. Res., 1972, 2(3): 179-184
Subject Codes: N/A
BIO: 55027929

422. LOTAN, J.E. Initial germination and survival of lodgepole pine seedlings onprepared seedbeds.
USDA For. Serv., Intermountain For. and Range Exp. Stn., 1974: Res. Note INT-29
Subject Codes: N/A
RCA: X1169

423. LOTAN, J.E., DAHLGREEN, A.K. Hand preparation of seedbeds improves spot seeding of lodgepole pine in Wyoming.
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1971, No. INT-148: 6 pp.
7 ref.
Subject Codes: 7.2, 7.6.1
CAB: 091252

Reports a trial in which Pinus contorta was spot-sown in June, 1967 on N-facing, 15- 45% slopes that had been logged and burned in 1966, in the Abies lasiocarpa/Vaccinium scoparium type. Seed was sown (a) in ash + litter, (b) on scalped 5" squares on the slope, (c) on scalped 12" squares on the slope, and (d) on scalped 12" squares on levelled benches. After three growing seasons, the ratio of viable seeds to seedlings was (a) 60:1, (b) 12:1, and (c) and (d) 5:1, and the percent of stocked plots was (a) 10, (b) 38, (c) 64 and (d) 72.

424. LOTAN, J.E., PERRY, D.A. Fifth-year seed: seedling ratios of lodgepole pine by habitat types and seedbed preparation technique.
USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1977, No. INT-239: 6 pp.
4 ref.
Subject Codes: 3.6, 4.3
CAB: 1032583

Further results are reported of a study of Pinus contorta. Seed/seedling ratios were highest on the Pinus contorta/Purshia tridentata habitat type and lowest on the Abies lasiocarpa/Vaccinium scoparium type (a). The ratios were inversely related to soil moisture. The best survival was achieved with site preparation techniques that increased available soil moisture and reduced competition. Ratios were sufficiently high in (a) even on untreated plots to provide acceptable stocking (3000 trees/ha) depending on available seed. Ratios after the 5th season were much higher than those after the 1st season, except in (a). The number of viable seed/ha required to produce 3000 trees/ha at 5 years is given for each habitat type and seedbed treatment.

425. THOMPSON, S. The growth of lodgepole pine seedlings raised under clear polythene

cloches at five seedbed densities.
Canadian Journal of Forest Research, 1980, 10(3): 426-428
16 ref.
Language: en
Summary Languages: fr
Subject Codes: 5.1, 5.2, 7.3
CAB: 1329431

Shoot growth and DM production were studied in 1+0 lodgepole pine seedlings raised under clear polythene cloches for 12 weeks at 5 seedbed densities (180-720 plants/m2). The greater plant ht. found at the highest seedbed density was the result of increased stem unit length, not increased number of stem units. The increase in plant dry wt. as seedbed density decreased was largely due to greater dry wt. of roots, branchwood and branch foliage, and not to increases in stemwood and stem foliage wt. Seedbed densities of less than 460 seedlings/m2 are required to produce yields of suitably sturdy seedlings in excess of 50% of the crop. From author's summary.

## 4.3 TYPES AND OCCURRENCE

426. ALDEN, T. et al. Some methods for vegetative propagation. IN: Vegetative Propagation of Forest Trees - Physiology and Practice, Lectures from a symposium in Uppsala, Sweden, 16-17 February, 1977.
Dep. For. Genetics, Coll. of Forestry, S-104 05 Stockholm, Sweden, 1977: 137-147
9 ref., 6 pl.
Subject Codes: N/A
CAB: 1202951

Methods for the propagation of Alnus sp., Betula sp., Picea abies, Pinus sylvestris and P. contorta by cuttings are described and illustrated schematically.

427. BOWEN, M.R., HOWARTH, J., LONGMAN, K.A. Effects of auxins and other factors on the rooting of Pinus contorta Dougl. cuttings.
Annals of Botany, 1975, 39(162): 647-656
30 ref.
Subject Codes: 2.3, 7.3
CAB: 556510

Describes the effects of applying NAA, IBA and boron (as boric acid), along or in combination, on the number and type of roots formed and the time taken to form first roots in P. contorta cuttings, mostly taken from selected trees representing hybrids between inland and coastal provenances. Cuttings treated with NAA produced fewer 'micro-roots' (finely branched roots ca. 0.6 mm in diameter) and more 'macro-roots' (unbranched at the time of examination, ca. 1.9 mm in diameter) than did the controls; the least number of micro-roots and greatest number of macro-roots were produced at the highest NAA concentration. A mixture of IBA and NAA produced results similar to those given by NAA alone. Application of IBA alone resulted in the production of numbers of each type of root generally similar to those produced by the controls. The time taken for the first roots to form, and the final number of rooted cuttings, were also greatly increased when the hormones were applied at dosages in the range 1-10 mu g per cutting. Boric acid applied in combination with hormone treatment increased rooting, but was ineffective when used alone. There were marked differences between clones in their rooting responses to both hormone and boron treatments.

428. BRANDT, K. Results of the Hedeselskab trial of propagation using cuttings.
Hedeselskabets Tidsskrift, 1979, 100(1): 8-10
2 pl.
Language: da
Subject Codes: N/A
CAB: 1022327

Preliminary results of propagation from cuttings in a new mist propagation greenhouse at the Society's forest seed centre at C.E. Flensborg plantation.

Rooting of some selected Picea abies clones from Hoersholm Arboretum averaged 96% (range 45-100%). In another program designed to produce Christmas tree material from late flushing mother trees, rooting averaged 97% (40-100%). In a trial to study the effect of age on later morphological development of cuttings, rooting percent was lower for trees aged 2-6 years than for very young material; however, rooting percent of some cuttings taken from 10-year-old P. sitchensis averaged 93% (80-100%). When cuttings were taken from grafted trees in clone collections, rooting averaged 45% (0-93%) for P. sitchensis and 13% (0-36%) for P. abies. In small-scale trials with other species P. contorta showed 70% rooting; Abies procera and A. nordmanniana averaged 40%.

429. BRIX, H., VAN DEN DRIESSCHE, R. Use of rooted cuttings in reforestation: a review of opportunities, problems and activities.
Joint Report, British Columbia Forest Service/Canadian Forestry Service, 1977, No. 6: 16 pp.
95 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.3
CAB: 892314

The advantages and problems of rooted cuttings are reviewed in terms of juvenility, genetic improvement, root system quality, growth form, wood quality, pest control, cost and time factors. Developments in various countries are reviewed. Reforestation in British Columbia is discussed for Pseudotsuga menziesii, Tsuga heterophylla, Picea glauca, Pinus contorta var. latifolia, Picea sitchensis and Chamaecyparis nootkatensis.

430. COPES, D.L. Graft incompatibility in Pinus contorta.
USDA For. Serv. Res. Note, Pacific NW For. and Range Exp. Stn., 1975, No. PNW-260: 9 pp.
3 ref.
Subject Codes: 1.3, 2.10
CAB: 769936

The results are presented of an anatomical study of top-cleft grafts, made 2-3 years previously, on native seedlings found growing near a seed orchard at Klamath Falls, Oregon. The characteristic symptom of incompatibility was a recessed xylem area where stock and scion xylem tissues were adjacent. In incompatible grafts, xylem growth ceased abnormally early or was very slow during the summer-wood period, while in contiguous non-union xylem areas normal growth continued. Unequal growth of adjacent cells resulted in recessed union areas that completely encircled the graft union. Compatible grafts had nearly equal growth in union and non-union zones and did not form recessed xylem areas. Phenotypic roguing of imcompatible grafts is accurate when done 2 or 3 years after grafting useful criteria are needle chlorosis and scion overgrowths. Anatomical tests for incompatibility are not necessary.

431. LARSEN, F.E., DINGLE, R.W. Vegetative propagation of lodgepole pine, Pinus-contorta, from needle fascicles.
Forest Sci., 1969, 15(1): 64-65
Subject Codes: N/A
BIO: 69034427

432. MORDEN, G., ROSS, J. Ponderosa and lodgepole pine rooting trials.
Tree Planters' Notes, 1976, 27(4): 10-13
3 ref., 2 pl.
Subject Codes: 7.3
CAB: 928052

Shoot cuttings from (a) 1+0 stems of lodgepole pine (Pinus contorta) and from (b) 1+0, (c) 2+0 and (d) 3+0 stems of ponderosa pine (Pinus ponderosa) were placed in a rooting chamber (RH almost 100%) and transplanted to a greenhouse (RH 35%) after 11 weeks. Survival after 17 weeks was 37, 7, 53 and 55% for (a), (b), (c) and (d) respectively. It is suggested that the relatively high mortality, particularly in (b), could be reduced by a longer rooting period and a more gradual transition from the environment of the rooting chamber to that of the greenhouse.

433. STREET, H.E., WEBB, K.J. Applications of plant tissue culture in forestry.
Report on Forest Research, Forestry Commission, UK, Bot. Lab., Leicester Univ., UK, 1976: 58-59
7 ref.
Subject Codes: 5.4
CAB: 796264

In continued work with Pinus contorta and Picea sitchensis, meristematic nodules have developed from the hypocotyl and cotyledonary regions of excised embryos and hormone-free medium. The same medium supported active growth of shoot tips of Pinus contorta seedlings. Studies are being made to induce root formation from these shoots. Attempts to isolate a haploid cell line from callus obtained from microsporangia have not been successful.

434. WHEELER, N.C., ANDERSEN, S. Container-grown seedlings make excellent rootstock.
Tree Planters' Notes, 1978, 29(2): 16-19
4 ref., 2 pl.
Subject Codes: 7.3
CAB: 1380414

A comparison was made of the suitability for grafting of container-grown and bare-rooted lodgepole pine seedlings. The container-grown and bare-rooted seedlings were potted up one year before grafting. Suitability was evaluated on the basis of total height, height to first branch node, diameter at base and diameter at grafting height. Container-grown seedlings were taller and had significantly greater lengths of graftable stem. They were easier to grow, maintain and transplant, and required less pruning.

## 4.4 SEROTINY

435. HAMILTON, D.A. Jr., WENDT, D.L.R. SCREEN: a computer program to identify predictors of dichotomous dependent variables.
USDA For. Serv. Gen. Tech. Rep., Intermountain For. and Range Exp. Stn., 1975, No. INT-22: 20 pp.
4 ref.
Subject Codes: 6.1, 6.2
CAB: 564394

Describes an algorithm for screening potential relations between dependent variables with only two possible values and a set of independent variables. Examples are given of possible applications in the study of: the presence or absence of a resistance mechanism against infestation by Dendroctonus ponderosae in Pinus contorta; regeneration, in order to predict the presence or absence of stocked quadrats; the presence or absence of cone serotiny in Pinus contorta; and the presence or absence of cull volume in apparently sound trees.

436. HARTL, D.L. Selection for serotiny in lodgepole pine Pinus-contorta-var-latifolia mathematical analysis of the model of Perry and Lotan.
Evolution, 1979, 33(3): 969-972
Subject Codes: 2.8
BIO: 69044193

The conditions for maintenance of a polymorphism by stochastic selection in a population undergoing partial self fertilization are presented. The model is of interest in understanding the dynamics of the serotiny polymorphism in natural stands of lodgepole pine (Perry and Lotan).

437. HELLUM, A.K. Cone moisture and relative humidity effects on seed release from lodgepole pine cones from Alberta.
Can. J. For. Res., 1982, 12(1): 102-105
Language: en
Summary Languages: fr
Subject Codes: 2.1, 2.8, 4.1
LISC: 655963

Cones from two stands of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) from southwestern Alberta were bulked for approximately 10 trees per location. The effects of cone moisture content and relative humidities (RH) on seed release within the extraction kiln were noted. Cone moisture content was the most important factor for seed extraction and the greater the moisture loss the more seed was released. Kiln RH of 10, 15 and 20% were equally effective, as was dropping the RH from 20 to 10% during extraction. A final RH of less than 10% probably is required for full seed release.

438. HELLUM, A.K., BARKER, N.A. Cone moisture content influences seed release in lodgepole pine.
Canadian Journal of Forest Research, 1980, 10(3): 239-244
27 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.8
CAB: 1315701

Seed release is closely associated with cone m.c. in lodgepole pine. M.c. varied between 12 and 16% in cones stored in unheated shelters in Alberta. M.c. between 15.5 and 18.5% was required to obtain full seed release in bulk lots of cones, depending on the lot. Past research has pointed out the variable nature of cone serotiny in lodgepole pine, and this study suggests that a large part of this variability is due to variable cone moisture. From authors' summary.

439. KASHYAP, S.C., LEWIS, J.E. Microwave processing of tree seeds.
J. Microwave Power, 1974, 9(2): 99-107
Subject Codes: N/A
BIO: 58069035

440. KNAPP, A.K., ANDERSON, J.E. Effect of heat on germination of seeds from serotinous lodgepole pine Pinus-contorta-var-latifolia cones.
Am. Midl. Nat., 1980, 104(2): 370-372
Subject Codes: 2.8
BIO: 71023304

The hypothesis tested was that the temperature required to release seeds from serotinous cones of lodgepole pine would have an adverse effect on germination. Seeds were mechanically removed from cones collected in southeastern Idaho (USA). Treatment groups heated to temperatures of 45-50 degree C, 60-65 degree C, 75-80 degree C, 90-95 degree C, and 105-110 degree C were compared to controls maintained at 20-25 degree C. There was no significant difference in germination between controls and treatment groups heated to temperatures up to and including 60-65 degree C. Seeds heated to 76-80 degree C and higher exhibited a significant decrease in germination. This suggests the existence of a threshold temperature above which germination is reduced. The threshold temperature coincides with the upper temperatures required to open serotinous cones.

441. LOTAN, J.E. Cone serotiny of lodgepole pine near Island Park, Idaho.
US Forest Serv. Research Paper, INT-52, 1968:1-6
Subject Codes: 2.8
BIO: 51092214

442. LOTAN, J.E. Cone serotiny in Pinus contorta.
Diss. Abstr. Int., B, Sci. Eng., 1971, 32(3): 1305-B
Subject Codes: 2.8
BIO: 72092907

443. LOTAN, J.E. The role of cone serotiny in lodgepole pine forests. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 471-495
42 ref.

Subject Codes: 2.8, 3.2
CAB: 769874

A review of cone production by Pinus contorta and the conditions conducive to serotinous cone opening and seed dissemination. The roles of serotinous cones, particularly in the rapid regeneration of lodgepole pine in an area following fire, and of nonserotinous cones are considered from ecological and silvicultural viewpoints.

444. LOTAN, J.E. Cone serotiny-fire relationships in lodgepole pine.
Proc. Annu. Tall Timbers Fire Ecol. Conf., 14, 1976: 267-278
Subject Codes: 2.8
BIO: 77017887

445. PERRY, D.A., LOTAN, J.E. Opening temperatures in serotinous cones of lodgepole pine.
USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1977, No. INT-228: 6 pp.
11 ref.
Subject Codes: 2.8
CAB: 950440

New, unopened cones and old, closed cones collected from 9 Pinus contorta var. latifolia trees in Idaho and Washington were classified as serotinous (90% closed cones), non serotinous (10% closed cones), or intermediate, stored for several weeks and immersed in a water bath at 35 deg. C. The temperature was raised in 5 deg. C steps until all cones were fully opened. Cones from serotinous, non-serotinous and intermediate trees opened in the ranges 40-60 deg. C, 24-50 deg. C and 35-50 deg. C, respectively. The temperature at which all cones of a given serotinous tree were open varied from 45-60 deg. C. Opening temperatures were different for old and new cones from the same tree.

446. PERRY, D.A., LOTAN, J.E. A model of fire selection for serotiny in lodgepole pine.
Evolution, 1979, 33(3): 958-968
Subject Codes: 2.8
LISC: 445373

Pinus contorta var. latifolia in the northern Rocky Mountains exhibits 2 cone types, one that opens at maturity and one that is opened only by heat exceeding 45 deg. C (serotinous). Cone serotiny is probably a genetic adaptation to fire with 1-locus, 2-allele control. Despite a history of repeated fires in the northern Rockies, the frequency of the open-cone phenotype remains high. Simulations suggest that observed phenotype frequencies have been produced by a selection regime in which the average selection coefficients have been 0, or very close to 0 with a high variance. This suggests fire patterns variable in time or in time and space. Certain characteristics of lodgepole pine ecosystems influence these patterns, and thus play a role in maintaining the cone-type polymorphism.

447. TEICH, A.H. Cone serotiny and inbreeding in natural populations of Pinus banksiana and Pinus contorta.
Can. J. Bot., 1970, 48(10): 1805-1809
Subject Codes: 5.4
BIO: 52013886

## 5.0 G R O W T H A N D Y I E L D

448. BENECKE, U., BAKER, G., MCCRACKEN, I.J. Tree growth in the Craigieburn Range. N.Z. FOR. Serv., For. Res. Inst., FRI Symp., (16), 1978: 77-98
Subject Codes: 2.0
BIO: 17015176

449. BOGGIE, R., MILLER, H.G. Growth of Pinus contorta at different water-table levels in deep blanket peat.
Forestry, 1976, 49(2): 123-131
22 ref.
Subject Codes: 2.11
CAB: 723942

A further report on this trial planted in NW Scotland in 1963 on plots where the water tables were artificially maintained at five depths (0-34 cm). Height increment was linearly related both to the depth of the water table and to air volume in the upper soil horizons. Stem volume, tree weight and foliage area increased exponentially over the range of treatments. Foliar N and P contents, although broadly related to treatment, were low and decreased with time: they did not increase as expected following canopy closure (when the soil became much dryer and height growth tended to accelerate).

450. COLE, D.M., EDMINSTER, C.B. 1985. Growth and yield of lodgepole pine. Pages 263-290 in Lodgepole pine: the species and its management. Symposium proceedings. Pullman, WA.

Stand growth and yield were estimated using whole stand growth models developed for managed stands in Colorado and southern Wyoming and for managed and unmanaged stands in Montana and Idaho. Potential production is estimated for various combinations of stand density, site quality, rotation age, and thinning schedules. Merchantable cubic volume production per unit area is maximized at relatively high stand densities. volume production substantially declines when managed stand density is reduced. The optimum stand density is related to site quality. Whether potential levels of production can be achieved depends on how much money can be invested in thinning and the importance, relative to timber values, of other resource values such as water yield, forage production, and recreation. In addition, stand densities may have to be maintained below optimum levels to minimize insect and disease problems. for most management considerations, cutting cycles of 30 years seem most feasible. Applicability of the models to other geographical areas is discussed.

451. CORNS, I.G.W. Tree growth prediction and plant community distribution in relation to environmental factors in lodgepole pine, white spruce, black spruce, and aspen forests of western Alberta foothills.
Ph.D. Thesis, Univ. Alberta, Edmonton, Alberta
Subject Codes: 3.0
RCA: X1076

452. DUMANSKI, J., WRIGHT, J.C., LINDSAY, J.D. Evaluating the productivity of pine forests in the Hinton-Edson area, Alberta, from soil survey maps.
Can. J. Soil Sci., 1973, 53(4): 405-419
Subject Codes: N/A
BIO: 57054638

453. HAGGLUND, B. Growth and yield in planted lodgepole pine stands in Finland and Sweden. In: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 167-179
11 ref.
Subject Codes: N/A
RCA: X1085

This paper summarizes a report written as part of the "HUGIN-project" in 1979 which presented a growth and yield model for lodgepole pine in Finland and Sweden. The model is based on research plot data whose provenances originated from latitudes between 49 deg. N and 55.5 deg. N in North America.

454. HANN, D.W., RIITTERS, K. A key to the literature on forest growth and yield in the Pacific Northwest: 1910-1981.
Forest Research Lab., Oregon State Univ., Corvallis, 1982, Research Bulletin 39: 77 pp.
Subject Codes: N/A
RCA: X1138

Tables are presented that summarize 108 published articles on forest growth and yield in the Pacific Northwest. Each table describes the form of the information presented, the species to which the information is applicable, the data sources used to develop the information, the data needed to predict growth and yield, and the form of the predicted data.

455. LONGMAN, K.A. Effects of gibberellin clone and environment on cone initiation shoot growth and branching in Pinus-contorta.
Ann. Bot. (Lond.), 1982, 50(2): 247-258
Subject Codes: 2.5, 2.11
BIO: 75041379

Effects of photoperiod, temperature and GA application were clearly separated from clonal differences when small rooted cuttings, originating from 2 floriferous trees of the same provenance of P. contorta Dougl., were treated with a simple micro-injection technique and grown in growth cabinets. Short days (10 h) for 11 weeks induced 6 times as many female cones as long days (19.5 h), completely inhibited further needle elongation after 5 weeks, and also led to enhanced branching by year 3. Cool temperatures appeared to favor male cone initiation in year 1, and (in conjunction with long days) significantly promoted height in year 2. Injection with 1 mg GA4/7 led to substantial and highly significant increases in bud growth in year 1, and in height, needle number and total needle length in year 2. GA treatment also increased branching but did not significantly affect internode elongation in year 2, nor cone initiation or needle elongation in year 1. Highly significant clonal differences occurred, with one geotype having longer leaves and buds in year 1, and up to 80% greater numbers and total lengths of needles in year 2. Marked clonal differences in height growth, branching and sex ratio were also found. The implications of both results and approach are discussed in relation to developmental physiology, genetic selection and advances in forestry research.

## 5.1 SINGLE AND STAND TREE VOLUME

456. ALEMDAG, I.S., HONER, T.G. Metric relationships between breast height and stump diameters for 11 tree species from eastern and central Canada.
Can. For. Serv. For. Manage. Inst. Info. Report FMR-X-49, 1977: 62 pp.
Subject Codes: N/A
BIO: 77089276

457. ALLEN, M.G., ADAMS, D.L., HOUCK, G.L., HATCH, C.R. Volume tables for small trees in northern Idaho.
Stn. Note, Forest, Wildlife and Range Exp. Stn., Univ. of Idaho, 1965, No. 27: 6 pp.
Subject Codes: N/A
CAB: 1216261

Small-tree volume equations and tables for Douglas-fir, western larch (Larix occidentalis), lodgepole pine and grand fir (Abies grandis) are given, as well as equations and tables for a composite stand. Volume data are provided in cubic feet and board feet. The tables are intended for use in the production of lumber from small logs.

458. BERRY, A.B. Metric form-class volume tables.
Info. Rep., Petawawa Ntnl. For. Inst., 1981, PI-X-10: iii: 24 pp.

3 ref.
Subject Codes: N/A
CAB: 1556616

Total volume equations and form-class volume tables are given for: Pinus banksiana; P. strobus; P. resinosa; P. contorta; Picea glauca; P. mariana; Abies balsamea; Thuja occidentalis; Betula papyrifera; B. alleghaniensis; Populus tremuloides; acer spp.; Fagus grandifolia; and Tilia americana.

459. CHAPMAN, R.C. Yield of small diameter trees in eastern Washington.
Project WNP00341, Washington State Univ., Pullman, WA, 01 Jul 76 to 30 Nov 79
Subject Codes: 5.2
CRIS: 0070829

Objectives: Develop accurate yield (volume) tables for Douglas-fir, ponderosa pine, lodgepole pine, and western larch in eastern Washington. Approach: Field

sample plots will be established throughout the region from which trees will be harvested, and determination made of age, dbh, stump height, form class, crown class, and height. Trees will be cut into four-foot sections and records made of green weight, stem position, diameter outside bark, and bark thickness. Green weight will be converted to oven dry by sampling. Yield (volume) tables will be constructed. Progress: Bole dry weight and bole weight-basal area models were developed for small diameter ponderosa pine. Models relating bole weight and cubic foot volume to top diameter are being developed. Models describing cubic foot volume, green and dry weight of small diameter ponderosa pine have been developed. A weight-basal area model was developed to facilitate prism cruising of small diameter stands. Data from this study is currently being used to develop taper models.

460. COLE, D.M. A cubic-foot stand volume equation (and volume table) for lodgepole pine in Montana and Idaho.
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1971, No. INT-150: 8 pp.
7 ref.
Subject Codes: N/A
CAB: 068001

461. COLE, D.M. Merchantable cubic stand volume conversion factors for lodgepole pine in Montana and Idaho.
Research Note, Intermountain For. and Range Exp. Stn., USDA For. Service, 1979, No. INT-259: 12 pp.
4 ref.
Subject Codes: N/A
CAB: 1455578

462. COLE, D.M., STAGE, A.R. Estimating future diameters of lodgepole pine trees.
US For. Serv. Research Paper INT-131, 1972: 1-20
Subject Codes: N/A
BIO: 73084770

Periodic diameter growth of lodgepole pine trees in Montana, Idaho, and Utah can be estimated by equations developed in this study. Use of these equations for estimating future diameters of individual trees is described for several combinations of tree and stand conditions.

463. FAUROT, J.L. Estimating merchantable volume and stem residue in four timber species: ponderosa pine; lodgepole pine; western larch; and Douglas-fir.
USDA FOR. Serv. Res. Paper, Intermountain For. & Range Exp. Stn., 1977, No. INT-196: 55 pp.
4 ref.
Subject Codes: 5.6
CAB: 1022409

Measurements were made of felled trees in western Montana. The methods of stem

measurement and volume computation are described. Tables are presented for estimating total cubic volumes of wood, wood residue from tops, bole sections and small unmerchantable stems, and bark for Pinus ponderosa, P. contorta, Larix occidentalis and Pseudotsuga menziesii. The tables apply to second growth trees up to 80 years old.

464. GALLAGHER, G.J. Permanent sample plots: data collection, storage and retrieval. IN: Permanent Plots in Forestry Growth and Yield Research. Proceedings IUFRO Subject Group S4.01, Warsaw, Poland, 1975.
Rapporter och Uppsatser, Institutionen for Skogsproduktion, 1976, No. 43: 57-66
6 ref.
Subject Codes: N/A
CAB: 1082908

For Picea sitchensis, P. abies, Pinus contorta, P. radiata, P. sylvestris, Pseudotsuga menziesii and Abies grandis in Ireland.

465. GIDEON, R.A., FAUROT, J.L. A model relating merchantable length to tree diameter and height.
Forest Science, 1977, 23(2): 143-150
8 ref.
Subject Codes: N/A
CAB: 817058

A nonlinear regression model relating merchantable length of a tree (i.e. length of bole from the stump to a predetermined top diam. limit) to d.b.h. and total ht., in combination with 3 or 4 unknown parameters (estimated by least squares method) was derived using a modified logistic growth function. The model was successfully applied to 4 species of different stem form in W. Montana - ponderosa pine (Pinus ponderosa), western larch (Larix occidentalis), lodgepole pine (Pinus contorta) and inland Douglas- fir (Pseudotsuga menziesii var. glauca).

466. HONER, T.G. Standard volume tables and merchantable conversion factors for the commercial tree species of central and eastern Canada.
Forest Management Research and Services Institute, Ottawa, Ontario, Information Report FMR-X-5, 1967: 153 pp.
Subject Codes: N/A
RCA: X1072

467. JOHNSTONE, W.D. Juvenile height growth of white spruce and lodgepole pine following logging and scarification in west-central Alberta.
Info. Rep., Northern For. Research Centre, Canada, 1976, No. NOR-X-171: iii + 10 pp.
Language: en
Summary Languages: fr
Subject Codes: 7.1, 7.6.1
CAB: 914722

Height/age regressions were developed from measurements of 68 Picea glauca and 216 Pinus contorta var. latifolia taken more than 10 years after scarification of clear-felled areas. Pine regeneration generally exceeded 1.8 m in ht. (the min. ht. for harvesting residual blocks) within 20 years, the usual cutting rotation in Alberta. In many areas, spruce did not reach this minimum, but as the growth rate exceeded 0.15 m/year this height would soon be reached.

468. KOVATS, M., SCHUMACHER, F.X., HALL, F.D.S. Estimating juvenile tree volumes for provenance and progeny testing.
Canadian Journal of Forest Research, 1977, 7(2): 335-342
6 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 878242

Information was collected from 100 trees 1-10 m tall of Picea engelmannii, P.

glauca, Pinus contorta and Psudeotsuga menziesii. The British Columbia volume prediction system, developed by F.X. Schumacher and F.D.S. Hall, was adapted for small trees by introducing a flexible ratio to allow the measurement of diam. to vary within a limited proportion of the total height. This is referred to as the diam. reference ratio, L/H, where L is the distance from the point of germination to the point of diam. measurement and H is the total height. The effects of different reference ratios on the regression equations and their standard errors were calculated and optimum ratios were determined. Volume equations are given for each species. Estimates using this method were consistent with those using the British Columbia Forest Service volume formulae for trees with heights greater than 1.3 m, the standard diam. reference height.

469. MACLEAN, C.D., BERGER, J.M. Softwood tree volume equations for major California species.
USDA For. Serv. Res. Note, Pacific NW For. and Range Exp. Stn., 1976, No. PNW-266: 34 pp.
5 ref.
Subject Codes: N/A
CAB: 843336

New cubic feet, international 1/4-in bd-ft and Scribner bd-ft tree-volume equations and tables are presented for Pseudotsuga mensiesii, Pinus jeffreyi, P. ponderosa, P. lambertiana, P. contorta, Abies concolor, A. magnifica and Libocedrus decurrens.

470. MOEUR, M. Crown width and foliage weight of northern Rocky Mountain conifers.
Res. Paper, Intermountain For. and Range Experiment Station, USDA For. Service, 1981, No. INT-283: 14 pp.
10 ref.
Subject Codes: 2.2, 5.6
CAB: 1514576

Equations were derived for predicting crown width of trees from diam., ht., crown length and b.a. per acre, and for predicting foliage wt. from diam., ht., crown length, age, relative diam. and number of stems/acre. Coefficients were estimated for 11 conifer species in northern Idaho and western Montana. The equations are intended for incorporation into a prognosis model for stand development to improve its linkage with sub-models for predicting insect damage, wildlife habitat and watershed characteristics. From author's summary.

471. MYERS, C.A. Board-foot volumes to a 6-inch top for lodgepole pines in Colorado and Wyoming.
US Forest Serv. Research Note RM-157, 1969: 1-3
Subject Codes: N/A
BIO: 70024700

472. PERSSON, A., LINES, R. (Chairman) Session II: Survival, height increment and growth increment. IN: Proceedings of the IUFRO Working Party Mtg. 1980 on Pinus contorta Provenances in Norway and Sweden.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1980, No. 30: 45-165
many ref.
Subject Codes: 1.4, 6.4, 7.3
CAB: 1358134

Larsen, J.B. Older provenance trials with Pinus contorta in Denmark. Fryk, J. Inventory of older Pinus contorta plantations at AB Iggesunds Bruk; and provenance trials - trial series B. Jonsson, A., Eriksson, G., Dormling, I. A summary of studies of frost hardiness of Pinus contorta seedlings grown in climatic chambers. Hagner, M. Geographic variation in Pinus contorta and Picea mariana with respect to cone size, seedling growth rhythm and cotyledons. In Alberta, Canada. Lindgren, D., Lindgren, K. Survival and height increment of Pinus contorta IUFRO 70/71 series in Sweden. Nellbeck, R. AB Iggesunds Bruks contorta plantations 1968-1980, program and experience. Rosvall, O. A new series of Pinus contorta provenance trials in northern Sweden. Thompson, S., Stapleton, C.M.A., Stevenson, A.W. Growth of lodgepole pine seedlings raised under clear polythene cloches in the UK.

473. SMITHERS, L.A. The cofrequency principle in diameter growth analysis.
Canada, Dept. of Mines and Resources, Dom. For. Serv., Silv. Res. Note No. 91, 1948
Subject Codes: N/A
RCA: X1033

474. WASS, E.F., SZABO, T. Estimating annual height growth by the internode method.
Bi-monthly Research Notes, 1973, 29(1): 1
Subject Codes: 2.5
CAB: 098581

The boles of young specimens of Pinus contorta var. latifolia, Picea glauca and Pseudotsuga menziesii were split and the pith was examined. The pith in all the trees was easily separated into annual-growth segments, as the pith contracted during drying and the resultant separation gaps clearly defined the correct end positions of the annual-growth segments, i.e. the true length of the internodes. These separation gaps never occurred in the centre of branch whorls but always some distance above the centre (details tabulated). The variation suggests that the distance between the centres of branch whorls and the true ends of internodes cannot be compensated by a simple constant term in a stem-analysis model or volume model.

475. YANG, R.C., KOZAK, A., SMITH, J.H.G. The potential of Weibull-type functions as flexible growth curves.
Canadian Journal of Forest Research, 1978, 8(4): 424-431
17 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1071346

A new growth function, which is flexible enough in shape to accommodate most biological growth behaviour, is created by adding an expanding factor to the Weibull distribution function. Many monotonically increasing biological growth phenomena can be excellently modelled by this function with various numerical values for the scale, the shape, and the upper asymptote parameters. The function is illustrated with ht./age and vol./age curves for single trees and two polymorphic stand vol./age curves, for lodgepole pine (Pinus contorta) trees from British Columbia. From authors' summary.

## 5.2 YIELD

476. ANON. Bias in yield prediction from temporary plots.
Prepared by W.R. Dempster and Assoc. for the Canadian Forestry Service, 1982
Subject Codes: N/A
RCA: X1104

477. BETTERS, D.R. A simulation model for analyzing timber-water joint production in the Colorado Rockies.
Tech. Bulletin, Colorado State University Experiment Station, 1975, No. 127: 10 pp.
5 ref.
Subject Codes: N/A
CAB: 676836

An account of work already noticed from an abstract describing a model for predicting annual timber and water yields over a number of years in Pinus contorta sub-alpine catchments.

478. DAHMS, W.G. Gross and net yield tables for lodgepole pine.
U.S. Forest Serv. Res. Paper PNW-8, 1964: 14 pp.
Subject Codes: 3.7

RCA: X1009

Gross and net yields together with site index curves are presented for lodgepole pine on pumice soils of central and south-central Oregon. To obtain gross yields, gross volume increment was measured on 94 plots and by means of a multiple regression equation related to the stand variables age, site index and stand density. Gross yield represents the cumulative summary of the increment equation obtained by integration with respect to age.

479. DAHMS, W.G. Gross yield of central Oregon lodgepole pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Svce., 1973, publ. 1975: 208-232
13 ref.
Subject Codes: N/A
CAB: 770107

New equations expressing volume increment as a function of age, stand density and site index were used to reanalyze gross yield data from 10-year volume increment measurements of Pinus contorta. The accuracy of the new equations was confirmed by comparing actual and estimated volume increment from sample plots of P. contorta in Wyoming and Colorado. Volume increment in Colorado/Wyoming was greater than that in central Oregon for the same age span, site index and stand density. Methods are explained for estimating site index and for fitting site index and height-growth curves.

480. DUFF, G. Yield tables for unthinned stands of the green varieties of Pinus contorta in New Zealand.
New Zealand Forest Serv. Tech. Paper, 1966, (50): 1-37
Subject Codes: N/A
BIO: 50083843

481. EDMINSTER, C.B. RMYLD: Computation of yield tables for even-aged and two-storied stands.
Res. Pap., Rocky Mountain For. and Range Exp. Stn., 1978, RM-199: 26 pp.
Subject Codes: N/A
LISC: 059595

Documents a program for computation of yield tables for even-aged and two-storied stands of Black Hills and southwestern ponderosa pine, Engelmann spruce-subalpine fir, and even-aged stands of lodgepole pine. Program relationships provide for changes in stand conditions and severity of dwarf mistletoe infestation with time and in response to partial cuttings.

482. FAUROT, J.L. Taper equations for the major commercial species of western Montana.
Project MONZ07910-MS, Univ. of Montana, Missoula, MON, 01 Oct 79 to 30 Sep 82
Subject Codes: N/A
CRIS: 0079856

Objectives: Develop taper equations for ponderosa pine, Douglas-fir, lodgepole pine, and western larch, primarily for tree sizes encountered in second-growth management. Approach: Two models will be tested, one a simple one where a single equation is used to describe the profile of the entire stem, and a second which will utilize two equations, one to describe root swell and another to describe the remainder of the tree stem. Only trees less than 80 years old will be examined.

483. GOUDIE, J.W. Yield tables for managed stands of lodgepole pine in northern Idaho and southeastern British Columbia.
Univ. of Idaho Grad School MSc. Thesis, 1980: 110 pp.
Subject Codes: N/A
RCA: X1162

484. GOUDIE, J.W. Interim yield tables for lodgepole pine in British Columbia.
Final Report for Research Project E.P. 850, Ministry of Forests, Victoria, B.C.
Subject Codes: N/A

RCA: X1106

485. GOUDIE, J.W., MITCHELL, K.J. Calibration of the tass growth model for lodgepole pine. E.P. 850.01. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 112
Subject Codes: N/A
RCA: X1070

486. HAMILTON, G.J., CHRISTIE, J.M. Forest management tables (metric).
Forestry Commission Booklet 1971, No. 34: 201 pp.
Subject Codes: N/A
RCA: X1010

Yield curves, production class curves, thinning regimes and normal yield tables are provided for 20 species including lodgepole pine.

487. HAWKSWORTH, F.G., MYERS, C.A. Procedures for using yield simulation programs for dwarf mistletoe infested lodgepole pine stands.
US For. Serv. Research Note RM-237, 1973: 1-4
Subject Codes: 6.2
BIO: 73091584

488. HEGYI, F., JELINEK, J., CARPENTER, D.B. Site index equations and curves for the major tree species in British Columbia.
Forest Inventory Report No. 1. Inventory Branch, Ministry of Forests, Province of British Columbia, 1979.
Subject Codes: 3.7
RCA: X1038

489. JOHNSTONE, W.D. Variable stand-density yields of natural lodgepole pine stands in Alberta. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 186-207
17 ref.
Subject Codes: N/A
CAB: 770106

Yield and growth characteristics of 792 natural stands of Pinus contorta were examined. A technique is presented for stratifying single-examination plot data in order to derive variable stand-density yield equations. Estimates of several stand characteristics, obtained over a range of age, site and stand-density conditions using this technique, are presented in appendices. From author's summary.

490. JOHNSTONE, W.D. Variable density yield tables for natural stands of lodgepole pine in Alberta.
Can. For. Serv. For. Tech. Rep. 20, 1976: 110 pp.
Subject Codes: N/A
BIO: 77089463

491. LAMB, K. Position statement, Canterbury Conservancy, New Zealand.
N.Z. For. Serv., For. Res. Inst., FRI Symp. (15), 1978: 368-371
Subject Codes: N/A
BIO: 16022450

492. LEE, Y. Predicting mortality for even-aged stands of lodgepole pine.
Forest Chron., 1971, 47(1): 29-32
Subject Codes: 2.1
BIO: 71038534

493. MYERS, C.A. Yield tables for managed stands of lodgepole pine in Colorado and Wyoming.
USDA For. Serv., Rocky Mountain For. and Range Exp. Stn., 1967: Res. Paper RM-26
Subject Codes: N/A
RCA: X1174

494. MYERS, C.A., HAWKSWORTH, F.G., STEWART, J.L. Stimulating yields of managed dwarf mistletoe-infested lodgepole pine stands.
US For. Serv. Research Paper RM-72, 1971: 1-15
Subject Codes: 6.2
BIO: 53010420

495. MITCHELL, K.J. Construction of lodgepole pine yield tables for Idaho.
Project IDA-ES-0141, Univ. of Idaho, Moscow, IDA, 01 May 77 to 08 Oct 81
Subject Codes: N/A
CRIS: 0074666

Objectives: Replace the parameters in the Douglas-fir simulator (forest Science Monograph 17) with values for lodgepole pine. Approach: Analyze the growth of the boles, branches and crown of trees from northern Idaho and southern B.C. Derive parameters for height and branch growth, foliage retention and distribution, bole increment, and genetic variation among trees. Calibrate the model to conform with permanent sample plot data. Generate managed stand yield tables. Progress: Additional calibration was undertaken prior to the preparation of a final report which is now in draft form.

496. NOKOE, S. Demonstrating the flexibility of the Gompertz function as a yield model using mature species data.
Commonwealth Forestry Review, 1978, 57(1): 35-42
6 ref.
Language: en
Summary Languages: fr, es
Subject Codes: N/A
CAB: 1118721

The flexibility of the function is demonstrated with data for mature trees of Thuja plicata, Pinus contorta and Pseudotsuga menziesii in British Columbia. Trends in the behaviour of the estimated coefficients in the model were detected. It is suggested that use could be made of such trends to evolve generalized yield equations for individual or combined species groups. From author's summary.

497. REMROD, J. A yield model for lodgepole pine in northern and central Sweden.
Sveriges Skogsvardsforbunds Tkidskrift, 1977, 75(1): 3-43
14 ref.
Language: sv
Summary Languages: en
Subject Codes: N/A
CAB: 856214

Data from stands of Pinus contorta, 20-50 years old in northern and central Sweden, were used to develop a yield model describing stand development under different conditions. The computer program for the model is given in an appendix. The model was used to compare the production of P. contorta with that of P. sylvestris. In planting P. contorta to increase wood production in northern Sweden, heavy thinnings should be avoided thus reducing the risk of losses from windthrow, snow and attack by Pityogenes chalcographus.

498. SMITH, J.H.G., YANG, R.C. Effects of species mixtures and inventory zones on net yields of British Columbia forests.
Forestry Chronicle, 1982, 58(2): 85-90
19 ref.
Language: en
Summary Languages: fr

Subject Codes: N/A
CAB: 1539605

A least squares procedure was developed for analyzing qualitative and quantitative data from irregular unbalanced forest inventories, and was applied to determine the relationship of species mixtures and inventory zones to net stand vol/ha. For 9,781 plots in Douglas-fir, spruce and lodgepole pine forest types, vol/ha was greatest when these species were mixed with other conifers, but small differences in age, site index and stand density could account for much of this variation. It is concluded that where stand density is used with age and site index to estimate yield, there is no need to recognize inventory zones other than coast and interior races within each species group.

499. SNELLGROVE, T.A. Timber quality and product yield potential of western softwood resources.
Projct PNW-3101, Pacific NW For. & Range Exp. Sta., Portland, ORE, 29 Oct 69 to 19 Feb 83
Subject Codes: 5.6, 6.1, 8.1
CRIS: 0000238

Objectives: Determine, evaluate, predict and prescribe product yield potential and utilization characteristics of western softwood timber as an aid to resource utilization. Approach: Product yield potential of standing dead timber, logging residue, and material below merchantable limits will be developed on a species by species basis. Study will determine resource characteristics, rates of dead timber deterioration, and above ground biomass. During the next 5 years, study will emphasize the utilization of standing dead timber caused by recent major insect infestations. Up-to-date recovery information and analytical grading systems will be developed to meet Forest Service and industry needs for data that reflect mill technology and resource changes. Emphasis will be given to major species that require product recovery on a cubic volume basis. Log and tree grades will be completed on species having systems considered inadequate for estimating value and yield. Studies will relate physical timber characteristics to yields. Western hemlock, the true firs, young growth ponderosa pine and western red cedar will receive primary attention. Progress: 80/10 81/09 The effect of mortality on deterioration for 6 western softwood species (lodgepole pine, ponderosa pine, western white pine, true fir, Engelmann spruce and western hemlock) has been studied but additional research is needed on all but western white pine. Results indicate that there are some volume and value losses in all species, but there is enough value retained to economically utilize much of the dead resource. Volume and value losses are directly related to such variables as time-since-death, environmental conditions and products produced. The changing size and quality of the software resource in the western United States, the introduction of new processing technology, departure from traditional product mixes, and the introduction of a different measurement (scaling) system all serve to complicate utilization of the western sawtimber. Research, on a continuing basis, investigates the relationship of these variables on product recovery. Much emphasis is being placed on relating the cubic volumes to product recovery.

## 5.3 STAGNATION

No references found.

## 5.4 GENETICS

500. ANON. The Foundation for Forest Breeding in Finland in 1979.
Helsinki, Finland, 1980: 32 pp.
Language: fi
Summary Languages: en
Subject Codes: N/A
CAB: 1238649

This report indicates that timber quality improvement is being intensified in Picea abies, Pinus sylvestris, Pinus contorta and Betula pendula. The Picea species collection was increased to 19 by the addition of seed from China of Picea asperata, P. koraiensis, P. likiangensis, P. meyeri, P. purpurea, P. schrekiana and P. wilsonii. The best of 120 seven-year-old cross progenies of B. penduala were 19% taller than the mean with a volume difference of 80%. Of a total of 539 birch progenies in trial, 34 had volumes which were 50% greater than the mean.

501. ANON. Yearbook 1978 of the Association of Forest Tree Breeding, Institute of Forest Improvement.
Uppsala, Sweden, 1979: 78 pp.
Language: sv
Summary Languages: en
Subject Codes: 1.4, 4.3
CAB: 1048199

Activities included the grafting of selected plus-tree clones of Picea abies and Pinus sylvestris, provenance trials of the above species and of Pinus contorta and progeny tests of spruce and pine. The results of a study with Pinus sylvestris showed that the quality of progenies of orchards was no better than that of progenies from stands.

502. ANON. Forest-genetic research 1980.
Rapporter och Uppsatser, Institutionen for Skogsgentik, Sveriges Lantbruksuniversitet, 1981, No. 31: 155 pp.
many ref.
Language: sv
Summary Languages: en
Subject Codes: 1.4
CAB: 1395140

An annual publication, now giving English summaries of each report. Descriptions and preliminary results are given of projects in progress at the department of Forest Genetics, Swedish University of Agricultural Sciences, Uppsala. The projects cover: provenance studies on Picea abies, Pinus sylvestris, Pinus contorta and Picea mariana; economics of forest tree breeding; breeding theory; factors influencing seed crop in seed orchards; enzyme, serological and monoterpene studies on P. sylvestris; frost resistance and growth studies on various species; genetic and physiological aspects of clonal forestry; and early selection at different spacings.

503. BLACKMAN, T. Genetics center moves toward objectives of tree improvement.
Forest Industries, 1978, 105(1): 64-65
2 pl.
Subject Codes: N/A
CAB: 878399

An account of the Weyerhauser Co.'s Klamath Forest Genetics Center at Malin, Oregon, established in 1972 for breeding high-yielding trees of Pinus contorta and P. ponderosa in an area isolated from pine forests. Scions from plus trees are grafted on to 4-yr-old rootstocks and produce cones which are hand fertilized with selected pollen. An experimental technique for direct rooting of pine cuttings has shown some success.

504. BURDON, R.D. The genetic basis of forestry in New Zealand. IN: 22nd FRI (Forest Research Institute) Symposium on Forest Nursery and Establishment Practice in New Zealand: Part 1. Nursery Practice, Mar.23-27, 1981.
New Zealand For. Serv. For. Research Inst., 1981, (22): 1-7
Subject Codes: N/A
BIO: 24001894

505. CHENG, C.Y, ILLINGWORTH, K., CARLSON, M. 1985. Geographic variation in lodgepole pine and its implications for tree improvement in British Columbia. In pages 45-53 in Lodgepole pine: the species and its management. Symposium

proceedings. Washington State University, Pullman, WA.

In response to an anticipated increase in the planting and intensive management of lodgepole pine, a comprehensive provenance program was initiated and a series of field tests were established in the interior of British Columbia in the early 1970's. These tests have been assessed periodically and the results are presented in this report. Lodgepole pine appears to be plastic; survival was better than 90% on even extremely harsh environments. coastal provenances, although suffering repeated winter injury, are still living. Site and provenance variables markedly affect the growth of lodgepole pine. After ten growing seasons, mean height of individual test plantations ranged from 1.4 to 4.8 m. Mean height of provenances varied from 0.3 to 2.25 m on poor growing sites and from 1.4 to 6.3 on good sites. These large differences suggest a potential for increasing the productivity of lodgepole pine plantations by planting selected seed sources on those sites, which could repay investments in intensive silviculture. The 140 provenances tested can bed immediately subdivided into two groups based upon response to interior test environments. Those from coastal, far southern and far northern continental environments exhibit poor cold tolerance and/or reduced growth; those from Alberta and the B.C. Interior suffer less cold- related damage and grow relatively well. Only the second group is of interest in out practical breeding programs. For these sources geographic variables of elevation and latitude can be used to explain some of the variation in growth response. In general, however, predictability of performance based on elevation and latitude of seed source is low. Several low- to mid-elevation provenances appear to be broadly adapted with successful transfers from source to planting site of +/- 3 deg latitude and up to 400 m in elevation. These provenances will provide interim sources of seed for reforestation, as well as selected trees for testing across many widely separated breeding zones throughout the more productive parts of the B.C. Interior.

506. CRITCHFIELD, W.B. Genetics of lodgepole pine.
Research Paper, WO-37, Washington, D.C., Forest Service, USDA, 1980: 57 pp.
Subject Codes: N/A
RCA: X1211

507. DANCIK, B.P., YEH, F.C. 1983. Allozyme variability and evolution of lodgepole pine Pinus contorta var latifolia and jack pine Pinus banksiana in Alberta Canada. Canadian Journal of Genetics and Cytology. 25(1):57-64.

Genetic variability in 5 lodgepole pine (P. contorta dougl. var. latifolia Engelm.) and 3 jack pine (P. banksiana Lamb.) populations from Alberta was analyzed electrophoretically for 14 enzymes presumably representing 21 structural loci, single populations of lodgepole pine were, on the average, polymorphic and heterozygous at 51.4 and 18.4% of their loci, respectively, and had 2.5 alleles/locus. Jack pine populations were less variable genetically; the average number of alleles/locus was 2.1, and 46 and 11.5% of their loci were polymorphic and heterozygous, respectively. Analysis of F-statistics showed a 2.5 and 9.7% deficiency of heterozygotes relative to Hardy-Weinberg expectations for lodgepole pine and jack pine populations, respectively. Only 2% of the observed genetic variability in each species appeared to be interpopulation, the remainder was due to differences among individuals within populations, in agreement with results from other conifers. Average genetic distance between the 2 spp. was 20 times greater (0.097) than between populations within species (0.005). The enzyme data were concordant with earlier hypotheses that the 2 spp. evolved from a common progenitor.

508. ERIKSSON, G. Current research at the department of forest genetics, the Royal College of Forestry, Stockholm.
Rapporter Och Uppsatser, Institutionen for Skogsgentik, 1972, No. 11: 58 pp.
53 ref.
Subject Codes: 1.4
CAB: 114094

Presents a survey of provenance research, progeny testing and seed-orchard research (all dealing mainly with Picea abies and Pinus sylvestris), and research on the value of isozymes for genetic studies. The provenance trials include a series of Pinus contorta plantations.

509. FECHNER, G. Tree improvement plan.
Project COL02260, Colorado State Univ., Fort Collins, COL, 01 July 78 to 30 June

81
Subject Codes: N/A
CRIS: 0078904

Objectives: Basic goals in the Tree Improvement program are to produce stock for planting in Colorado that is genetically superior in adaptation to that currently being used: increase forest production on state and private lands in Colorado through the application of genetic principles; and bring about legislation requiring the labelling of the source of the forest tree seed and of the woody planting stock shipped into and out of Colorado. Approach: Establish interim and collection zones throughout the state for all first and second-priority species. Initiate testing of seed collection (within state provenance studies). Such work will invoice collection of open-pollinated seed from several trees of each species studied (especially first and second priority species) within each seed collection zone. Seedlings will be outplanted in replicated plots in their different test locations. Initiate testing of performance of exotics and hybrids. Establish seed production areas for all first priority species in each of the four state regions. Progress: Test plantations were established of several species on agricultural land in Weld and Jackson counties, Colorado: Windsor, Weld County: Hybrid poplars - 2 reps of 16 N.E. hybrids, 2 reps of 10 N.E. hybrids, 29 "extras"; 81 total trees; 0.30 acres. Narrowleaf cottonwood - 3 blocks, 22-tree plots of each of 81 Colorado sources per block: 972 total trees; 3.84 acres. Colorado State Forest, Jackson County: lodgepole pine - 3 single-tree plots of 149 sources, plus 2 single-tree plots of 2 sources; sources from Montana, Wyoming and Colorado; 451 total trees; 1.25 acres. Scotch pine - 3 single-tree plots of each of 53 USSR sources; 227 total trees; 0.75 acres. Initial measurements were taken on new plantations, and continuing measurements were taken on previously-established Scotch pine, ponderosa pine, and hybrid poplar plantations. Tests of germination under several moisture-stress regimes were carried out for Colorado, Oregon and hybrid Douglas-fir seeds. Seedlings from the germination tests were grown in the greenhouse for future outplantings.

510. GURIES, R. Forest tree improvement through selection, breeding and seed production - Phase V.
Project WIS01826, Univ. of Wisconsin, Madison, WIS, 01 Jul 72 to Sep 86
Subject Codes: 4.1
CRIS: 0060888

Objectives: To select and breed the second and succeeding generations of several tree species utilizing existing region-wide provenance tests as the base populations. To select and test additional species and selected strains to meet special needs. To implement the regional distribution to action agencies of important tree species developed in earlier phases of the program. Approach: Using information accumulated during earlier phases of the project, breeding zones will be established. Breeding methods will involve breeding and research populations for use in selection and advanced generation activities, and production populations for providing improved seed in commercial quantities. Breeding and research populations will involve subpopulations to produce advanced generations of known relatedness. The best selections in each generation will be used to establish production populations by action agencies. Progress: Analysis of allozyme data from lodgepole pine indicates that average heterozygosity for this species is similar to other conifers studied to date (H = .09-.14), and that little population differentiation has occurred throughout western North America in this species. Over 90% of the detected variation resides within populations. An examination of introgression between jack and lodgepole pine using allozyme data shows that reciprocal gene exchange is common following hybridization events but may be of a transient or geographically limited nature. Population genetic structure and genetic diversity analyses in pitch pine demonstrated that this species is only weakly differentiated, and genetic and geographic distances are only weakly correlated. Height growth measurements in the jack pine "index populations" revealed that selection of the tallest individuals within the best families would lead to gains in growth rate ranging between 15-22% above plantation average at 4 years of age. Future measurements will be needed to determine whether these expected gains can be realized in the long run. The jack pine plantings established in 1979 for the NC-99 flowering study have begun strobili production. Although flowering is still limited, early results suggest that warmer, drier locations are conducive to enhanced strobili production.

511. HEDRICK, P.W., THOMSON, G. 1986. A two-locus neutrality test applications to humans Escherichia coli and lodgepole pine. Genetics. 112(1):131-156.

The expected disequilibrium between two loci with K allele at one locus and L alleles at the other is given for a sample of size N drawn from a population

under neutrality equilibrium. three different measures of disequilibrium with 95% intervals are tabulated for combinations of N, K, L and 4NC, where N is the effective population size and C is the amount of recombination between the loci. The extent and pattern of disequilibrium are strongly dependent upon 4NC and are somewhat dependent on N, K and L. The 95% intervals are large, particularly for low numbers of alleles and low values of 4NC, as examples, observed disequilibrium from histocompatibility loci in humans (HLA) and electrophoretic data in E. coli and lodgepole pine were compared to these theoretical values. Using information about recombination rates, the HLA data showed more disequilibrium than neutrality expectations, whereas electrophoretic data from E. coli and lodgepole pine had somewhat less disequilibrium than neutrality expectations.

512. HOFF, R.J., MCDONALD, G.I., REHFELDT, G.E. Genetics and pest resistance of Rocky Mountain conifers.
Project INT-1451, Intermountain For. and Range Exp. Sta., Moscow, IDA, 28 Aug 74 to 30 Sep 84
Subject Codes: N/A
CRIS: 0041529

Objectives: Provide genetic classification of seed zones and breeding units; provide appropriate tree improvement techniques that emphasize natural fitness characters, including pest resistance, but simultaneously work to improve growth and quality. Develop a variety of white pine resistant to blister rust that has high stability in respect to the blister rust fungus. Approach: Determine the patterns of genetic variation as they relate to habitat, elevation, and geographic area, understand the relationship between genetic variation and fitness characteristics, develop an understanding of how host-pest systems evolve, determine the mechanisms of resistance in western whie pine to blister rust. This is a multifunctional research work unit involving timber management and forest disease research. Progress: (80/10 81/09) Seed orchard-grown western white pine with multiple stems produced more cones and pollen than did trees with single stems. Genetic gains of up to 14% can be realized for height growth of southern Idaho ponderosa pine. Differentiation of populations of lodgepole pine is due primarily to stand temperature. Seed transfer rules for northern Idaho Douglas-fir stress the restricted nature of populations of Douglas-fir to specific sites. Survival and height growth performance of coastal and inland western white pine growing in northern Idaho show very small differences, emphasizing the lack of among-stand differentiation. Differential defoliation of Douglas-fir by spruce budworm provides an opportunity to select for resistance to budworm. Resistance of 18 species of white pines to white pine blister rust ranked the resistant variety of western white pine as moderate. Also, western white pine appears to have several of the same resistance types that are present in the highly resistant white pine for which blister rust is an endemic disease, and computer-based model of white pine blister rust epidemics will be used to make stand hazard determinations to predict the longevity of existing white pine trees and to predict the usefulness and need of the various mechanisms of resistance.

513. JONSSON, A. Light or darkness - life or death for young Pinus contorta.
Sveriges Skogsvardsforbunds Tidskrift, 1980, 78(1/2): 163-169
4 ref.
Language: sv
Summary Languages: en
Subject Codes: 7.3, 7.4.3
CAB: 1407104

The results of trials carried out at the Swedish University of Agricultural Sciences, Stockholm, over several years with various P. contorta provenances indicate that photoperiod, rather than temperature, is the main factor in the hardening of P. contorta seedlings. With certain temperature limits, the thermoperiod has a modifying effect on the process. In an effort to find methods usable in early tests to predict frost hardiness, it was found that hardiness correlated negatively with growth of the needles in short shoots during the week preceding the freezing test and positively with the DM of the tops of the seedlings.

514. KNOWLES, P. Relative contributions of spatial and temporal heterogeneity to the genetic composition of lodgepole pine Pinus contorta. IN: UBC 2nd Intn'l. Congress of Systematic and Evolutionary Biology, Vancouver, B.C., Canada, July 17-20, 1980.
I+441 pp, University of British Columbia, Vancouver, B.C., Canada, 1980, Paper

0(0): 259
Subject Codes: N/A
BIO: 21055439

515. KNOWLES, P., MITTON, J.B. Genetic heterozygosity and radial growth variability in Pinus contorta.
Silvae Genet., 1980, 29(3): 114-118
Language: en
Summary Languages: de
Subject Codes: 5.1
LISC: 608152

The relationship between heterozygosity level and stability in the phenotypic character, annual radial growth, was examined within a population of P. contorta. Needle tissue was sampled from 152 pines in Colorado. Heterozygosity levels were determined from 4 electrophoretically detectable enzymes from the needle tissue. Each tree was cored, ages were estimated, and ring widths were measured. The coefficient of variation, a measure of dispersion in growth increment, was calculated for each tree and related to the level of heterozygosity. The results indicated that trees with overall high levels of heterozygosity had significantly less growth variability than trees with low levels of heterozygosity. When the loci were examined separately, there were no significant differences between the genotypic groups. This suggests a complex interaction among the 4 loci involved. These results suggest a strong relationship exists between heterozygosity and phenotypic variability.

516. KORMUTAK, A. Cytological evidence for incompatibility in the genus Pinus.
Biologica, Czechoslovakia, 1975, 30(10): 765-769
13 ref.
Subject Codes: N/A
CAB: 540014

Compatibility was studied in the following crosses: Pinus contorta X P. mugo, P. contorta X P. banksiana, P. mugo X P. banksiana, P. sylvestris X P. mugo and P. banksiana X P. sylvestris. It was found that gametophytic incompatibility in P. contorta X P. mugo, P. mugo X P. banksiana and P. banksiana X P. sylvestris was cuased by complete inhibition of the growth of the pollen tubes.

517. KOSKI, V. Proposed tree breeding programme in Finland, 1976-1985. Abbreviation of the report issued by the Tree Breeding Committee (Committee Report 1975: 25).
Folia Foestalia, Institutum Forestale Fenniae, 1976, No. 266: 24 pp.
Subject Codes: N/A
CAB: 939751

The program includes Pinus sylvestris, Picea abies, Betula verrucosa (B. pendula), B. pubescens, Populus tremula, Alnus glutinosa, A. incana, Salix spp., Larix spp. and Pinus contorta var. latifolia. Properties to be improved include rate of growth, adaptation and resistance, stem form and wood quality.

518. LAST, F.T. Trees and genes.
Scottish Forestry, 1977, 31(4): 225-243
Subject Codes: N/A
BIO: 78040543

519. MORGENSTERN, E.K. Interaction between genotype, site and silvicultural treatment.
IN: Proceedings of the Eighth World Forestry Congress, Jakarta, 16-28, Oct. 1978.
Petawawa For. Exp. Sta., Chalk River, Ont., 1978, FID-I/17-18: ii + 20 pp.
74 ref.
Subject Codes: N/A
CAB: 1191671

Results from a literature review are briefly discussed and presented in tabular form for 38 experiments on 21 species. It is concluded that most interactions are related to climatic and soil differences between the parental and progeny environments, and to differences in genetic buffering of the tested populations.

520. MOSS, E.H. Natural pine hybrids in Alberta.
Can. Jour. Research, 1949, No. 27:218-229
Subject Codes: N/A
RCA: X1216

521. OSTROLUCKA, M.G. Saccharides of the pollen of some species of the genus Salix and Pinus.
Biologia (Bratisl.), 1978, 33(7): 573-582
Language: sk
Subject Codes: N/A
BIO: 67015142

Qualitative and quantitative determinations were made in the pollen of selected species of Salix and Pinus (S. caprea, S. medemii, S. aurita, S. cinerea, S. dasyclados, S. apenina, S. purpurea, S. elaeagnos. S. hookeriana, S. daphnoides, Pinus sylvestris, P. mugo, P. banksiana, P. contorta) by paper chromatography in order to judge a possible relation between these metabolites and ability to cross-breed. Content of pollen saccharide in single species may play an important role as regards pollen germination and the ability of pollen tubes to grow. From the qualitative spectrum, sucrose is the dominant saccharide. Species with well-developed ability to cross-breed tend to have a higher sucrose content suggesting some significance in connection with pollen vitality and associated ability to cross with another species.

522. PARROT, L. Forest genetics.
Fonds. Rech. Forest., Univ. Laval, Bull. 12, 1968: 12 pp.
Subject Codes: N/A
BIO: 70059782

523. PERRY, D.A., LOTAN, J.E. Variation in lodgepole pine Pinus-contorta-var-latifolia greenhouse response of wind pollinated families from 5 populations to day length and temperature soil.
Can. J. For. Res., 1978, 8(1): 81-89
Subject Codes: 2.1, 2.11, 3.0
BIO: 66014263

Seeds were collected from 10 lodgepole pine trees in each of 5 stands located in Utah, Montana, Idaho, Washington (USA) and British Columbia (Canada). Seeds were planted and seedlings grown in 4 day-length regimes (14, 15.5, 16.5 and 22 h) in each of 2 temperature regimes (warm and cool). Soils used in the warm and cool treatment were slightly different. Height and dry weight were recorded. Variability among families within populations was considerably greater than that among populations. If interactions between families of the 2 cone types (open and closed) are removed, correlation between among-family variances and differential family response to day length and temperature-soil treatments is strong for dry weight ($r^2 = 0.96$), and less strong for height ($r^2 = 0.51$). Families from open- and closed-cone mothers did not have different heights and dry weights, but in at least some of the populations they were different in the degree of among-family variability. Correlation between greenhouse and 5th yr heights of field planted seedlings was poor for individual families, but good ($r^2 = 0.92$) for mean population heights. Correlation between 5th yr mean population heights and site index of the parent stand was also good ($r^2 = 0.89$).

524. REHFELDT, G.E., HAMILTON, R.C., WELLS, S.P. Genetic gains from mass selection in lodgepole pine.
Intermountain Stn. For. Sci. Lab., Moscow, ID 83843, USA
Subject Codes: N/A
LISC: 545099

The possible genetic gains from mass selection were quantified for 3 populations of Pinus murrayana on the Targhee National Forest in southeast Idaho. The formula used was: $\Delta G = Sh^2$ where $\Delta G$ = genetic gain, S = selection differential, and $h^2$ = heritability. Percentage gains were estimated for a range of heritabilities. Mass selection can provide relatively inexpensive but efficient procedures for genetically improving the growth of P. murrayana.

525. REHFELDT, G.E. 1985. Prospects for tree improvement in lodgepole pine. Pages 55-60 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

To realize genetic gains in productivity, tree improvement must maintain both adaptedness and the quality of secondary economic traits. Adaptation is partially reconciled by establishing breeding zones within which populations are adaptationally similar. For lodgepole pine of northern Idaho, for example, breeding zones should be elevationally narrow (200 m). Genetic variability within zones portends substantial genetic gains, including increases in height of 10 to 15 percent. Traits, however, are not inherited singly. Selecting a breeding population for height alone will increase substantially the number and length of branches, the number of whorls, and the duration of shoot elongation. Thus, gains in growth will be accompanied by maladaptation and by a deterioration in quality. The breeding strategy must seed the optimum compromise among growth, adaptation and form.

526. SZIKLAI, O. Plus tree selection of Pinus contorta var. latifolia in central British Columbia.
Faculty of Forestry, University of British Columbia
Subject Codes: 4.1
RCA: X1107

527. WERNER, M., HADDERS, G., ROSVALL, O. Breeding programme for Scots pine, Norway spruce and lodgepole pine.
Association for Forest Tree Breeding, Institution of Forest Improvement: Yearbook, 1980, Uppsala, Sweden, 1981: 59-111
48 ref.
Language: sv
Summary Languages: en
Subject Codes: 1.4
CAB: 1418890

A new 10-year breeding program for Swedish forest trees is described and discussed. For this, Sweden has been subdivided into 20 breeding zones for Pinus sylvestris, nine for Picea abies and six for Pinus contorta. At least one seed orchard will be established for each breeding zone. The programs for Pinus and Picea are presented diagramatically and described under the following headings: base populations, phenotypic "plus tree" selection, grafting of plus trees, progeny tests and evaluation, geotypic selection of elite clones or plus trees, grafting of elite clones, and establishment of first-generation seed orchards. These last-named orchards are to be established after preliminary screening.

528. YEATMAN, C.W., TEICH, A.H. Genetics and breeding of jack pine and lodgepole pine in Canada.
Forest Chron., 1969, 45(6): 428-433
Subject Codes: N/A
BIO: 51063459

529. YEH, F.C., CHELIAK, W.M., DANCIK, W.M., ILLINGWORTH, K., TRUST, D.C., PRYHITKA, B. 1985. Population differentiation in lodgepole pine, Pinus contorta ssp. latifolia: a discriminant analysis of allozyme variation. Canadian Journal of Genetics and Cytology. 27(2):210-218.

Seeds from 249 trees in 17 populations representing most of the species range in the Yukon and British Columbia were analysed for electrophoretically demonstrable variation in 16 protein coded by 23 genetic loci. On average 64% of the loci per population were polymorphic and expected and observed heterozygosity per population were 0.165 and 0.174 respectively. Univariate F-ratio tests for homogeneity among populations indicated genetic differentiation (P 0.05) at 6 loci. Two significant canonical discriminant functions accounted for 38% of the total variance in the 20 polymorphic loci. A complex relationship between genetic variation and geography was found. Both lat. and alt. appeared to be important, with N. populations showing a greater extent of genetic differentiation.

530. YEH, F.C., LAYTON, C. The organization of genetic variability in central and marginal populations of lodgepole pine Pinus-contorta-ssp-latifolia.
Can. J. Genet. Cytol., 1979, 21(4): 487-504
Language: en
Summary Languages: fr
Subject Codes: 4.0
BIO: 70002591

A survey was conducted of genetic variation at 25 loci in extracts of individual megagametophytes of lodgepole pine. Collections were made in 9 widely separated localities representing 4 marginal, 2 interemediate and 3 central populations. Single populations of lodgepole pine were polymorphic at 58.67% of their loci, and had 1.90 alleles/locus. Both expected and observed heterozygosity averaged 0.16. There was a definite trend towards decreased genetic variability at the margins. The measures of gene diversity for the 25 loci showed a 4% but significant effect of interpopulation differentiation; 96% of the total gene diversity resided within populations. Estimated outcrossing rates (.hivin.t) for the 9 populations ranged 0.92-1.29. Comparisons among populations with different levels of outcrossing revealed no clear relationship between (.hivin.t) and amount of genetic variability. The overall pattern of genetic differentiation agrees with expectations based on the neutral mutation theory. Loci (2) demonstrated conspicuous clinal variation patterns which may be incompatible with this stochastic model.

## 5.5 ROTATION AGE

531. SUNDBERG, C.G. Pinus contorta, an exotic which has come to stay.
Svensk Papperstidning, 1976, 79, No. 12: 372-373
Language: sv
Subject Codes: 7.4
CAB: 676854

Briefly discusses provenances, yield, rotations, etc. Because of its fast early growth it is possible to plan for rotations of 50-65 years, compared with 75-120 years for Swedish Pinus sylvestris. For this reason, it is thought that the species can play an important role in bridging the 'yield-gap' threatening Swedish forestry in ca. 50 years' time because of the unfavourable age distribution in the native forests. The state forests plan to plant 85,000 ha of P. contorta in the next decade, and a recent study has shown that state and industrial forests together plan to plant it on about 30,000 ha annually, i.e. 10% of the whole annual regeneration area.

## 5.6 BIOMASS

532. ADAMOVICH, L.L. Engineering characteristics of Canadian trees - centre of gravity and green weight of components of three conifers in interior British Columbia on poor growing sites.
Info. Rep., Forest Management Inst., Canada, 1975, No. FMR-X-82: vi + 67 pp.
6 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 564625

In this continued study, values for centre of gravity and for green weights of whole trees above ground and their main components were derived from sample trees of Picea engelmannii, Abies lasiocarpa and Pinus contorta var. latifolia growing on medium to poor sites in different bioclimatic zones in interior British Columbia. Values for centre of gravity were similar in both studies, but green weights were found to differ between poor and good sites and between species. New

tables are presented to assist in the design and operation of new timber-harvesting machines at higher elevations or on less fertile soils than those concerned in the previous study.

533. BELANGER, J. Inventory of logging residue in western white spruce and lodgepole pine stands.
IN: Proceedings 3rd Bioenergy R and D Seminar, March 24-25, 1981, Ottawa. Sponsored by National Research Council: 77-81
Language: en
Summary Languages: fr
Subject Codes: 8.4
RCA: X1129

The line intersect method was used to inventory downed logging residue from tree-length operations in western white spruce and lodgepole pine stands near Hinton, Alberta. For comparison purposes, the logging residue on 15 circular sample plots, each containing .04 ha, was weighed.

534. BROWN, J.K. Predicting crown weights for 11 Rocky Mountain conifers. Paper presented at XVIth International Congress of IUFRO, Oslo, Norway, June 22, 1976.
Orono, Maine, USA, College of Life Sciences and Agriculture, University of Maine, 1976: 101-115
13 ref.
Subject Codes: 2.2
CAB: 830780

Regression equations are presented relating live and dead crown wt. to d.b.h., crown length, tree ht., and crown ratio, and relating the fractions of crown wt. in foliage and branch wood of four diam. classes to d.b.h. in Pseudotsuga mensiesii, Picea engelmannii, Abies grandis, A. lasiocarpa, Pinus contorta, P. ponderosa, P. monticola, P. albicaulis, Tsuga heterophylla, Larix occidentalis and Thuja plicata.

535. BROWN, J.K., SNELL, J.A.K., BUNNELL, D.L. Handbook for predicting slash weight of western conifers.
USDA For. Serv. Gen. Tech. Rep., Intermountain For. & Range Exp. Stn., 1977, No. INT-37: 35 pp.
9 ref.
Subject Codes: N/A
CAB: 950379

Tables are presented for estimating either slash weight per tree by species and d.b.h. or slash weight per ft2 of tree basal area by species and d.b.h. The tables predict total slash from crowns and unmerchantable bole tips to 3-, 4-, and 6-inch diam. limits or slash less than or greater than 3" in diam. for 10 species of the western USA. Estimates of slash less than 3" in diam. were 15, 22 and 37% less than weights inventoried by the planar intersect method for Pinus ponderosa, Pseudotsuga menziesii and Pinus contorta, respectively. Estimated weights of total slash varied from 4% more to 15% less than inventoried weights.

536. CHAPMAN, R.C. Evaluation and modelling of biomass yields from conifer stands in inland northwest.
Project WNP00426, Washington State Univ., Pullman, WA, 24 May 78 to 30 Sep 83
Subject Codes: N/A
CRIS: 0076228

Objectives: Development of individual tree biomass equations for each of the major softwood species in the Inland Northwest. Development of statistical models to describe the distribution of biomass with a stand for each tree component (boles, branches and foliage) based on a variety of utilization standards (top diameters), and the accumulation of biomass over time. Modification of existing volume simulators or development of new simulators which can be used to evaluate many alternative energy production strategies such as optimum species selection and composition and selection of appropriate silvicultural treatments. Approach: Stand representation of species combinations, age classes and habitat types will be sampled in the field, and lab determinations made of oven dry yield. Statistical models will be designed to provide distribution of biomass within a stand for each tree component. These models will be used to strengthen existing volume simulators or if necessary for the development of new simulators, to

evaluate alternative energy production strategies. Progress: The primary emphasis during the year has been on oven drying and weighing of sample material. Ninety-five percent of this task is now completed. Cubic foot volume and green weight regression equations for small diameter stems have been developed for a variety of conifer species in northeastern Washington. A taper equation and a technique for using the equation to estimte product yields of small diameter ponderosa pine has been completed and published. An evaluation of the U.S. forest Service procedures for selecting genetically superior Douglas-fir has been completed and a manuscript describing the results has been written and reviewed internally. It is currently being revised for submission to a professional journal. The study verified that with respect to such phenotypic characteristics as diameter at breast height, total height, crown width, crown ration and board foot volume that the trees classified as being superior were in fact superior to selected comparison trees in the same stand. The conclusion of the study being that the U.S. Forest Service procedures will, when used carefully, result in the selection of phenotypically superior Douglas-fir.

537. CHAPMAN, R.C. 1985. Lodgepole pine biomass models. Pages 291-295 in Lodgepole pine: the species and its management. Symposium proceedings. Pullman, WA.

Although considerable attention has been devoted to estimating the cubic and board foot volume of lodgepole pine, much less attention has been devoted to developing models for predicting biomass of entire stems or of stem components. Results of a biomass study completed in northeastern Washington are reported. The study was focused on the development of biomass models for small diameter conifers. One hundred and two lodgepole pine stems were destructively sampled during the study. Linear regression techniques were used to develop biomass models. Weighted regression models are presented for predicting oven-dry bole biomass, total above-ground biomass, and the vertical distribution of bole biomass for stems greater than 15.2 cm in diameter at breast height. Weight basal area models and their behavior are discussed.

538. CHAPMAN, R.C., BALDWIN, V.C., CLAUSNITZER, R.R. Cubic foot volume, bole green weight and total above ground green weight of small diameter lodgepole pine, larch and ponderosa pine.
Agric. Res. Center, Wash. State Univ., 1982, Res. Bulletin XB 0914: 7 pp.
6 ref.
Subject Codes: N/A
RCA: X1120

A biomass study was initiated in 1978 with the objectives of developing individual aboveground biomass equations and modifying the "Stand Prognosis Model" (Stage, 1973) to provide estimates of small tree biomass yields under a variety of conditions. Some preliminary results of this study are presented including estimates of average individual tree bole volumes and green weights of small diameter lodgepole pine, ponderosa pine, western larch, and Douglas-fir in NE Washington.

539. DOBIE, J., MCINTOSH, J.A. Spruce foliage yields more than triple that of pine according to a study by the Western Forest Products Lab on the whole-tree logging of lodgepole pine and spruce in Alberta.
Pulp and Paper Canada, 1976, 77(10): 71-72
3 ref
Subject Codes: N/A
CAB: 724128

Whole-tree samples of lodgepole pine (Pinus contorta) and white spruce (Picea glauca) were taken and analyzed at a mill yard in July-Aug. 1975. The green weight of commercial foliage was 2.8% of total tree green weight in pine and 8.6% in spruce. Dry weights of whole trees needed for one ton of dried commercial foliage were estimated to be 13 tons for spruce and 42 tons for pine. Weights of foliage as a % of total weight were low compared with previous studies, possibly owing to losses during whole-tree transport.

540. FOULGER, A.N., FREESE, F., LENGEL, J.E. Solid wood content of western softwood logging residues.
USDA For. Serv. Res. Paper, Forest Products Laboratory, Madison, 1976, No. FPL 253: 7 pp.
6 ref.
Subject Codes: 8.4
CAB: 676686

Reports studies on fresh green residues of Abies lasiocarpa, Abies concolor, Pseudotsuga menziesii, Larix occidentalis, Pinus contorta, P. ponderosa and Picea engelmannii from Arizona, Oregon, Wyoming and Montana, USA, compared with data for residual branches (9 inches in diameter) from the Western Wood Density Survey. The wood content increased rapidly with increasing diameter of piece to 4 inches o.b. and then remained fairly constant; the relation varied with species, but not significantly with location. The %s of bark, foliage and wood are tabulated for pieces less than 0.25 inches in diameter. It is suggested that material less than 4 inches in diameter should be left in the forest as soil cover and as a source of soil nutrients.

541. FOULGER, A.N., HARRIS, J. Volume of wood, bark and needles after clearcutting a lodgepole pine stand.
J. For., 1973, 71(2): 93-95
Subject Codes: 7.5
BIO: 73052167

542. GARY, H.L. Crown structure and distribution of biomass in a lodgepole pine stand.
USDA For. Serv. Res. Paper, Rocky Mountain For. and Range Exp. Stn., 1976, No. RM-165: 20 pp.
37 ref.
Subject Codes: 2.2
CAB: 687647

Gross dimensions and quantities of needles and branches are presented for 298 trees. Weight, diameter, length, and height relations were usually highly correlated. Needles were normally distributed along the length of branches as well as vertically through the canopy. Needle and branchwood weights for entire crowns were best estimated by the logarithmic transformation of diameters at breast height. Author's summary.

543. JOHNSTONE, W.D. Dry-matter production and complete-tree utilization of lodgepole pine in Alberta.
Dissertation Abstracts International, B, 1973, 34(6): 2392-2393
Subject Codes: 2.10, 3.7
CAB: 702049

Presents results of studies of the dry-matter production, growth and complete-tree utilization of 100-year-old trees of Pinus contorta var. latifolia, compares the yield of dry matter from 100-year-old stands of different densities and on different sites, and compares the total standing crops above ground of younger P. c. var. latifolia and Populus stands, of similar ages and grown on similar sites. Data were collected from 100-year old trees of P. c. var. latifolia in two stands of average density and one of high density. Of the independent variables tested, the combined variable of (d.b.h.) 2 X total height was most closely associated with the dry weights of tree components. The combined variable of stand b.a. X mean stand height was closely associated with dry weights per acre of most tree components for trees from a range of sites and stand densities. For the sites examined, the above-ground total crop of younger P. c. var. latifolia was substantially higher than that of similarly aged Populus on similar sites. Reasons for the differences in productivity are discussed. Variations within and between trees in radial cross-sectional area were examined for twenty 100-year-old P. c. var. latifolia trees in thinned and unthinned stands. Volume growth was highly correlated with amount of foliage, but growth per unit of foliage was not related to tree size. Equations are presented for relating the amount of growth at any point in the tree to the needle mass at or above that point. Thinning did not appear to affect the pattern of growth. Data are presented on the yield and quality of kraft pulp from various components (e.g. branch, root stump, merchantable stem) of trees in stands of average and high density.

544. KIIL, A.D. Weight of the fuel complex in 70 year old lodgepole pine stands of different densities.
Can. Dep. Forest and Rural Development, Forest Br. Dep. Publ., 1968, (1228): 1-9
Subject Codes: N/A
BIO: 50061211

545. KIIL, A.D. Estimating weights of tree components of lodgepole pine from large-scale aerial photographs.
Can. J. For. Res., 1971, 1(3): 193-195
Subject Codes: N/A
BIO: 53054757

546. MCCARTHY, R. The energy potential of forest biomass in Ireland.
Irish Forestry, 1979, 36(1): 7-18
Subject Codes: 3.6, 7.4
CAB: 1273060

As part of an EC Energy Project, plots of 12 species were established on (a) blanket bog at Ross, (b) raised bog at Tullamore, (c) drumlin-gley soil at Swanlinbar and (d) podzol with discontinuous iron pan at Kilfinane. Fertilizer was applied on (a), (b) and (d) but not (c). Growth and survival at 2 yr old suggested that spruce and lodgepole pine grew best on the poor sites whereas broadleaves seemed to favour the better soils at (c) (although Eucalyptus was indifferent). Populus 'Fritzi Pauley' and Eucalyptus suffered badly in the Jan. 1979 frosts (after the above assessment) and may not recover. Survival of Salix spp. (planted as unrooted cuttings) was zero at (a), (b) and (d) and 100% at (c), the site with total yields of Sitka spruce at very close spacing up to 88 t/ha (at 27X6 cm spacing) 3 yr after transplanting. The potential is discussed for energy production from forest wastes and from special biomass plantations.

547. MAXWELL, W.G., WARD, F.R. Photo series for quantifying forest residues in the ponderosa pine type; ponderosa pine and associated species type; lodgepole pine type.
USDA For. Serv. Gen. Tech. Rep., Pacific NW For. and Range Exp. Stn., 1976, No. PNW-52: iii + 73 pp.
4 ref., 27 pl.
Subject Codes: N/A
CAB: 782858

Six series of photographs display different amounts of forest residue by size classes, for areas of similar timber type and felling practice. Information provided with each photograph includes measured weights, volumes and other residue data, data about the timber stand and harvest or thinning activities, and fuel ratings. The series provide a simple means for quantifying and describing existing and expected residues.

548. MILLER, E.L., MCCORMICK, J. Evaluation of tree species for environmental amelioration and energy production.
Project NEV00671, Univ. of Nevada, Reno, NEV, 01 Oct 78 to 30 June 83
Subject Codes: N/A
CRIS: 0076539

Objectives: Develop recommendations for using tree species in the production of energy and to modify environmental conditions. Approach: Tree plantings with a reasonable known history will be evaluated as to performance and cultural requirements; tree sub-stations which represent distinctly different climatic conditions will be selected and a species testing program initiated. Replicated plots will be used at each location to determine tree performance in regard to survival, growth, cultural requirements and pest resistance. Progress: In May, 1981, a species trial including sixteen species or varieties of conifers was initiated in Elko County, Nevada. Trees included were Pinus sylvestris (East Anglia, Haute Loire, Burgos, central Sapin), Pinus griffithi, Pinus nigra, Pinus contorta var. latifolia, Pinus flexilis, Pinus peuce, Pinus aristata, Picea abies (Germany, Finland, Austria), Sequoiadendron giganteium, Cupressus arizonica and Cupessus sempervirens. A drip irrigation system was utilized to provide adequate water for establishment. In October mean survival for all species was 94%, ranging from 76% for P. peuce to 100% for P. abies (Germany), and P. sylvestris (E. Anglia). During the same month field trials at the Ag. Exp. Ste. Main Farm, Reno, Nevada, were expanded to include five additional species or sources of poplar species. These included: Populus simonii, P. trichocarpa (2 sources), P. angustifolia and P. maximowiczii x trichocarpa. In southern Nevada (Holly Park), spacing trials using Tamarix aphylla were started in April. Spacings of 0.9, 1.8 and 3.6 metres were utilized in a windbreak planting. Height growth after the first growing season was not influenced by the indicated spacings, field trials of 5 pine species were initiated in the fall. Species included Pinus pinaster, P. halapensis (2 sources), P. elderica, P. pinea and P. roxburgh. All trials are

utilizing drip irrigation systems to insure initial establishment.

549. MOGREN, E.W. Small-tree biomass values, selected central Rocky Mountain species by habitat.
Project COLZ05303, Colorado State Univ., Fort Collins, COL, 01 Oct 79 to 30 Dec 81
Subject Codes: N/A
CRIS: 0079762

Objectives: Develop allometric equations for biomass determination of small size trees of selected Central Rocky Mountain species; present biomass values for these species in table form, using independent variables that can be easily measured in the field, include as one of the variables in the determination of biomass values, the habitat type or site conditions in which the tree is growing. Approach: Collect data for five species, Engelmann spruce, sub-alpine fir, lodgepole pine, ponderosa pine, Douglas-fir. Two groups of trees, based on size, will be recognized within each species: those under 1.4 m tall and those over this total height. The following tree components will be estimated by the models: Stem (bole) wood, stem (bole) bark, branch wood and branch bark will be considered as a single component; measurements will include some or all of the following: tree diameter in cm at 1.4 m on bole, at base of stem above root collar, at base of live crown; tree height in m, ht. to base of live crown, percent of total ht. in live crown. When the tree measurements are completed, the tree will be collected in total, or selected parts, and brought into the laboratory for weight determination. Progress: All field data collected and analyzed. Laboratory measurement completed. Modelling to determine allometric equations for predicting biomass of seedling and small poles for lodgepole pine, ponderosa pine, sub-alpine fir and Engelmann spruce has been completed. Two equations for each component tree part (bole, bark, leaves, branches) weights has been developed. The first equation limited to independent variables normally included in standard forest inventories. The second equation included those independent variables that resulted in the highest R. Biomass production in relation to habitat types was explored. Trends were evident in the data but no significant relationships were found.

550. MOIR, W.H. Litter, foliage, branch and stem production in contrasting lodgepole pine habitats of the Colorado Forest Range. IN: Proceedings - Research on Coniferous Forest Ecosystems - A Symposium, Bellingham, WA, Mar. 23-24, 1972.
Pacific NW For. and Range Exp. Stn., 1972: 189-198
20 ref.
Subject Codes: 7.6
CAB: 114161

Presents data for biomass and biomass increment in three stands of Pinus contorta and for annual litter fall during 1967-70 in these and three other stands with a table of stand biomass. The mean annual litter production was 0.46 kg/m2; the periodic (but not annual) litter fall in different stands appeared to depend on canopy mass. It is concluded that controlled surface fires may be the best means of improving the productivity and structure of these stands, whose yield is low. The stands studied for biomass production have been described elsewhere.

551. MOIR, W.H., FRANCIS, R. Foliage biomass and surface area in three Pinus contorta plots Colorado.
Forest Science, 1972, 18(1): 41-45
14 ref.
Subject Codes: N/A
CAB: 059785

Studies were made in forests already described in three plots of contrasting density and site index: (a) 1600 stems/ha, site index 40; (b) 8600 stems/ha, 60; and (c) 3800 stems/ha, 90. Foliage biomass and surface area were measured on felled sample trees in five d.b.h. classes. Although the mean dry weight of fascicles varied with dominance, crown position and fascicle age, no consistent pattern of variation was found in all three plots. Total over-dry leaf biomasses were (a) 0.49, (b) 0.84 and (c) 1.74 kg/m2; leaf area indices were (a) 4.5, (b) 4.5 and (c) 14.0 m2/m2. The leaf area index appeared to be a better index of total (biomass) productivity than the site index.

552. PETERSON, E.B., LEVSON, V.M., KABZEMS, R.D. Upper limits of standing crop density for woody species in the prairie provinces.
Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-243, 1982: 55 pp.
21 ref.
Languages: en
Summary Languages: fr
Subject Codes: 5.1, 5.2
RCA: X1039

Young tree and shrub stands in Alberta, Saskatchewan and Manitoba were sampled in 1979 to obtain estimates of maximum standing crop density. Aboveground standing crop values double the regional averages were found, with upper limit dry weights of 16.9 t/ha for a 2-year-old aspen-alder stand, 18.1 t/ha for a 4-year-old aspen-alder stand, and 29.6 t/ha for a 5-year-old aspen stand. Some young stands achieved standing crop densities comparable to those of fully closed mature stands. Recorded standing crop densities included 2.16 kg/m3 for an 8-year-old willow stand, 1.66 kg/m3 for an 8- year-old lodgepole pine stand, and 1.19 kg/m3 for a 9-year-old alder stand. Equations for predicting foliage dry weight, wood dry weight, and total aboveground dry weight from independent variables of stem diameter, stem height, stand age, and number of stems per hectare yielded results of low reliability.

553. SINGH, T. Weight tables for important tree species in the prairie provinces.
Northern Forest Research Centre, Canadian, Forestry Service, Edmonton, Alberta, For. Manage. Note No. 14, 1982: 4 pp.
Subject Codes: N/A
RCA: X1131

554. SINGH, T. Biomass equations for ten major tree species of the prairie provinces.
Environ. Can., Can. For. Serv., North For. Res. Cent. Edmonton, Alberta, 1982: Inf. Rep. NOR-X-242
Subject Codes: N/A
RCA: X1132

555. SNELL, J.A.K., BROWN, J.K. Handbook for predicting residue weights of Pacific Northwest conifers.
Gen. Tech. Rep., Pacific Northwest For. and Range Experiment Stn., USDA Forest Service, 1980, PNW-103: iv + 44 pp.
13 ref.
Subject Codes: N/A
CAB: 1539603

Procedures are given for estimating weight of potential residues (foliage, live and dead branchwood and unmerchantable tips) from logging and thinning of managed Douglas-fir and western hemlock stands west of the summit of the Cascade Mountains. Weight tables for these and estimates for 6 other species (Pinus ponderosa, P. contorta, P. monticola, Larix occidentalis, Thuja plicata, Abies grandis) give weights in lb/tree for residues with diameter of less than, or more than and equal to 3", for 6- or 8-inch diameter unmerchantable tips. A separate procedure is described for estimating weight of defective and broken stems.

556. SWEET, G.B., WAREING, P.F. A comparison of the seasonal rates of dry matter production of 3 coniferous species with contrasting patterns of growth: Larix-leptolepis, Pinus-contorta, Pinus-radiata.
Ann. Bot. (London), 1968, 32(128): 721-734
Subject Codes: 2.0
BIO: 50032960

557. SWEET, G.B., WAREING, P.F. A comparison of the rates of growth and photosynthesis in 1st year seedlings of 4 provenances of Pinus-contorta.
Ann. Bot. (London), 1968, 32(128): 735-751
Subject Codes: 1.4
BIO: 50032961

558. WEAVER, T., FORCELLA, F. Biomass of 50 conifer forests and nutrient exports associated with their harvest.
Great Basin Nat., 1977, 37(3): 395-401
Subject Codes: 3.3
BIO: 66045645

Biomasses of climax Rocky Mountain forests (USA; encompassing the following species: Abies lasiocarpa, Picea engelmannii, Pinus contorta var. latifolia, P. ponderosa, P. albicaulis, Pseudotsuga menziesii and Populus tremuloides) studied ranged from less than 50 to more than 300 tons/ha. Total biomass was approximately 1.5 times the biomass of normally merchantable boles. When compared with conventional bole harvest, the nutrient exports associated with harvest of all aboveground parts in these stands would apparently be at least 3 times higher for N, 6 times higher for P, 4 times higher for K, and 3 times higher for Ca.

## 6.0 DAMAGE

559. BELLA, I.E. 1985. Pest damage incidence in natural and thinned lodgepole pine in Alberta. Forestry Chronicle 61(3):233-238.

Young natural stands dominated by Pinus contorta thinned in 1972 or 1977- 81, or left unthinned, were sampled at 15-25 yr old. Overall, of 2065 unthinned and 899 thinned trees, the rates of attack were about 18% and 30% respectively for western gall rust (Endocronartium harknessii) and 16 and 25% for leader damage due to the weevil pissodes terminalis and pitch twig moth (Petrova spp.). Damage by other pests, such as needlecast infection (Lophodermella spp.), snowshoe hares (Lepus americanus) and red squirrels (Tamiasciurus hudsonicus) was generally low.

560. BELLA, I.E. 1985. Western gall rust and insect leader damage in relation to tree size in young lodgepole pine in Alberta. Canadian Journal Forest Research. 15(5):1008-1010.

In a sample of 121 young lodgepole pine (Pinus contorta var. latifolia) stands in naturally regenerated felled blocks near Hinton, strong positive correlations were observed in the incidence of gall rust (Endocronatrium harknessii) and leader damage from terminal weevil (Pissodes terminalis) and from pitch twig moth (Petrova spp.) with tree size in both thinned and unthinned stands. It is concluded that although tests on a selected number of the largest trees from each plot showed N.S.D. in incidence of the 2 pest categories between thinned and unthinned stands, thinning that retains the large trees may result in an increase in relative incidence of these pests unless special effort is made to fell damaged trees and retain undamaged ones.

561. GEISZLER, D.R., GARA, R.I., et al. Fire, fungi, and beetle influences on a lodgepole pine ecosystem of south-central Oregon.
Oecologia, 1980, 46(2): 239-243
Subject Codes: 3.0
CAB: 1340287

Interactions between fire, fungi, bark beetles and lodgepole pine (Pinus contorta) growing on the pumice plateau of central Oregon are described. Dendroctonus pondersae Hopk. outbreaks occur mainly in forests that are 80-150 years old with a mean tree diameter of about 25 cm and weakened by a fungus, Phaeolus schweinitzii. The outbreak subsides after most of the large diameter trees are killed. The dead trees fuel subsequent fires, which return nutrients to the soil, and a new age-class begins. The surviving fire-scarred trees are prone to infection by the slow fungal disease, and about 100 years later these trees are then susceptible to attach by D. ponderosae.

562. KARLMAN, M. Damage to Pinus contorta in N. Sweden.
Sveriges Skogsvardsforbunds Tidskrift, 1979, 77(2): 87-94
17 ref., 4 pl.
Language: sv
Summary Languages: en
Subject Codes: 6.2, 6.6
CAB: 1071807

Damage recorded in 1978, due to various causes, is described. In late winter 1978, elk and voles damaged P. contorta in a provenance trial, established in 1974, in Vasterbotten, N. central Sweden. All the 96 plots were affected, and in certain provenances more than 70% of the seedlings were seriously damaged. In October, 1978, a foliage disease, caused by Discella strobilina, was found on 2.5-year old P. contorta seedlings in a nursery in Vasterbotten. This is the first record of this fungus on P. contorta in Sweden. Unlike some other fungal diseases reported earlier, this disease was not associated with the choice of too southerly a provenance. It is pointed out that although P. contorta has proved superior to P. sylvestris in certain areas, especially in highlands regenerated with difficulty, its resistance to pathogens native to Sweden is still insufficiently known.

563. KARLMAN, M. Damage to Pinus contorta in N. Sweden in 1979.
Sveriges Skogsvardsforbunds Tidskrift, 1980, 78(3): 14-26
23 ref., 9 pl. (4 in col.)
Language: sv

Summary Languages: en
Subject Codes: N/A
CAB: 1369223

A continuation of observations in P. contorta plantations, where damage had been reported in 1978. Climate in winter 1979 varied from extremely cold to mild; this led to damage to P. contorta in provenance trials in Norrland, Angermanland and Vasterbotten. Mainly southern, but also some northern provenances were affected. A majority of plants injured by vole and elk in 1978 had recovered, but quality impairment seemed inevitable. Gremmeniella abientina and Sclerophoma pithyophila were found as secondary pathogens. Phacidium infestans affected provenance trials in Angermanland (where, since the planting in 1971, 16% of the plants have been killed by the disease) and Arvidsjaur. P. contorta remained resistant to Melampsora pinitorqua and Lophodermella sulcigena, both widespread in 1979 on P. sylvestris.

564. KARLMAN, M. Damage to Pinus contorta plantations in northern Sweden. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus Contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 247-255
27 ref.
Subject Codes: N/A
RCA: X1089

A survey of different kinds of damage to Pinus contorta provenance trials is made. The effects of unfavourable weather conditions, severe icing-up of plants, browse damage, insect pests and fungi are discussed with special reference to northern Sweden.

565. KARLMAN, M., LUNDH, J.E., MARTINSSON, O. Instructions for the determination of the most common type of damage to Scots pine, lodgepole pine and Norway spruce in regeneration areas and trial plantations in Sweden.
Sveriges Skogsvardsforbunds Tidskrift, 1982, 80(3): 24 pp.
16 col. pl.
Language: sv
Subject Codes: 7.1, 7.4
CAB: 1556902

Damage caused by fungi, insects, climatic and miscellaneous biotic and abiotic factors is described. Scales are proposed for the assessment of the severity of the damage.

566. MARTINSSON, O. Pinus contorta: what are the risks?
Sveriges Skogsvardsforbunds Tidskrift, 1978, 76(5): 435-440
3 pl.
Language: sv
Subject Codes: 6.1, 6.2
CAB: 1032863

A discussion of potential dangers from: American rust fungi attacking hard pines including P. contorta and P. sylvestris, many of which have alternate hosts in Scandinavia (the most important are Endocronartium harknessii, Cronartium coleosporioides, C. comandrae and C. comptoniae); the ascomycete Atropellis piniphila; the dwarf mistletoe Arceuthobium americanum; and bark beetles (especially Dendroctonus ponderosae). While the rusts are considered beneficial for natural thinning in the over-dense naturally regenerated stands prevailing in Canada, they could be very dangerous in Swedish plantations and accidental introduction should be guarded against with greater care. It is stressed that the practice of importing scions of plus trees for grafting is dangerous since no symptoms of fungus attack would be visible on cuttings made in winter.

567. PERSSON, A., LINES, R. (Chairman). Session VI: Diseases, insect pests and other damage. IN: Proceedings of the IUFRO Working Party Mtg. 1980 on Pinus contorta Provenances in Norway and Sweden.
Rapporter och Uppsatser, Institutionen for Skogsgentik, 1980, No. 30: 221-262
many ref.
Subject Codes: N/A
CAB: 1358135

Stephan, B.R. Diseases, insect pests and other damage in Pinus contorta as an exotic species. In central Europe. Hagner, M. Frost rings in provenances of Pinus sylvestris grown in Sweden and in autochthonous Pinus contorta. Karlman, M. Damage to Pinus contorta plantations in northern Sweden. Martinsson, O. How dangerous are the North American pathogens to the Scandinavian lodgepole pine.

568. SALT, G.A. Conifer seedling pathology.
Great Britain Forest Comm. Rep., Forest Res., 1970: 174-175
Subject Codes: 6.1, 6.2
BIO: 71042058

569. SHRIMPTON, D.M. Cellulolytic enzymes enhance wound response in lodgepole pine.
Can. For. Serv., Bi-monthly Research Notes, 1975, 31(2): 13-14
Subject Codes: N/A
BIO: 76007985

570. STEPHAN, B.R. Diseases, insect pests and other damage in Pinus contorta as an exotic species. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 221-230
25 ref.
Subject Codes: N/A
RCA: X1087

The phytopathological situation of Pinus contorta when grown as an exotic tree species is discussed. Examples are given of fungi, pests and abiotic agents dangerous or potentially dangerous with special reference to central European conditions.

571. THIES, W.G., HARVEY, R.D. Jr. A photographic method for measuring defect.
Can. J. For. Res., 1979, 9(4): 541-543
Subject Codes: 1.2
BIO: 18055558

572. WHITNEY, H.S. Association of Dendroctonus ponderosae (Coleoptera: Scolytidae) with blue stain fungi and yeasts during brood development in lodgepole pine.
Canadian Entomologist, 1971, 103(11): 1495-1503
19 ref.
Subject Codes: 6.1, 6.2
CAB: 052129

Studies were made from 1965 to 1967 on the physical association between D. ponderosae and its associated bluestain fungi Ceratocystis montia and Europhium clavigerum, and the yeasts Pichia pini, Hansenula capsulata and H. holstii. Observations on single broods reared in bolts of Pinus contorta var. latifolia are described. Eggs just before hatching, and the first-instar larvae, were always in contact with the micro- organisms, whereas newly laid eggs and second-, third-, and fourth-instar larvae were not. During pupation, bluestain fungi and yeasts colonized the pupal chamber walls. The micro-organisms were transferred to the new generation of insects when tenerals contacted them on the lining of the pupal chamber. The ensured physical contact between these organisms supports the hypothesis of a symbiosis between them.

## 6.1 INSECT

573. ANON. Effort to save lodgepole pine.
GC&HTJ, 1978, 183(26): 7
1 pl.
Subject Codes: N/A

CAB: 972550

An aerial spraying method new to the UK was adopted by the Forestry Commission in its attempts to control destruction of Pinus contorta by the pine beauty caterpillar (Panolis flammea) in Sutherland and Caithness, Scotland, where 240 ha have been lost. Fenitrothion (300 g/ha) with glycol in a ULV area application was used over 1 148 ha, producing smaller droplets likely to settle in tops of trees where the pest occurs. Areas within 2 miles of houses and roads received high volume sprays. Possible hazards to fish and wildlife, thought to be small, are being monitored.

574. AMMAN, G.D. Some factors affecting oviposition behavior of the mountain pine beetle.
Environ. Entomol., 1972, 1(6): 691-695
Subject Codes: N/A
BIO: 55055259

575. AMMAN, G.D. Mountain pine beetle brood production in relation to thickness of lodgepole pine phloem.
J. Econ. Entomol., 1972, 65(1): 138-140
Subject Codes: 2.4
BIO: 54001604

576. AMMAN, G.D. Prey consumption and development of Thanasimus-undatulus: a predator of the mountain pine beetle.
Envion. Entomol., 1972, 1(4): 528-530
Subject Codes: N/A
BIO: 72088787

577. AMMAN, G.D. Population changes of the mountain pine beetle in relation to elevation.
Environmental Entomology, 1973, 2(4): 541-547
17 ref.
Subject Codes: N/A
CAB: 267083

Populations of Dendroctonus ponderosae were studied in stands of Pinus contorta at four altitudes between 1 923 and 2 750 m in Wyoming, in 1968-69. The beetle had a 1- year life cycle at 1 923 and 2 130 m alt., but two years were normally required to complete the life cycle at 2 573-2 750 m. Cool temperatures at high altitudes delayed development, so that the beetle overwintered in stages that were particularly vulnerable to winter conditions. It is concluded that adverse weather conditions are responsible for the high mortality rates of beetle populations at high altitudes.

578. AMMAN, G.D. Insects affecting lodgepole pine productivity. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Education Service, 1973, pub. 1975: 310-341
60 ref.
Subject Codes: N/A
CAB: 770055

A brief review of the effects of insects that attack the seeds and cones, shoots, needles and bark of Pinus contorta. Bark beetles, particularly Dendroctonus ponderosae, are the most serious insect threat to merchantable lodgepole pine and are capable of causing almost complete destruction of a stand during a single infestation. Management practices are discussed for controlling beetle populations.

579. AMMAN, G.D. Abandoned mountain pine beetle galleries in lodgepole pine.
USDA For. Serv. Res. Note, Intermountain For. and Range Exp. Stn., 1975, No. INT-197: 6 pp.
16 ref.

Subject Codes: N/A
CAB: 556754

Galleries of Dendroctonus ponderosae were examined in recently attacked Pinus contorta var. latifolia in Idaho and Wyoming. Galleries with no females comprised 33% of those examined, and it is concluded that they had been abandoned as a result of a low incidence of fertilization; only one example of 'pitching out' (female beetles becoming trapped in resin) was recorded.

580. AMMAN, G.D. Incidence of mountain pine beetle abandoned galleries in lodgepole pine.
Research Note, Forest Service, USDA, 1980, INT-284: 6 pp.
11 ref., 2 fig.
Summary Codes: N/A
CAB: 1394973

Individual lodgepole pines (Pinus contorta) in Wyoming, Idaho and Utah had lower densities of attack by Dendroctonus ponderosae Hopk. and a higher percentage of abandoned egg galleries in stands where beetle populations were small rather than large. Most trees contained some galleries having live beetles, as well as abandoned galleries. Females from galleries likely to be abandoned had mated, discounting the unfertilized female as a reason for gallery abandonment. The amount and quality of blue-stain fungi (Certaocystis montia (Ceratostomella montium)) carried by the beetle might influence the success of gallery construction.

581. AMMAN, G.D. Characteristics of mountain pine beetle reared in four pine hosts.
Environ. Entomol., 1982, 11(3): 590-593
Subject Codes: N/A
LISC: 665497

Mountain pine beetles, Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae), obtained from naturally infected lodgepole pine, Pinus contorta var. latifolia Engelmann, were reared in four common hosts: ponderosa pine (P. ponderosae Lawson); western white pine (P. monticola Douglas); whitebark pine (P. alibicaulis Engelmann); and lodgepole pine. Emerging beetles were collected daily, counted, and sexed, and pronotal width was measured. Significant differences in brood production, size of female beetles, and developmental rate, but not sex ratio, occurred among hosts. Differences were not all associated with the same species of tree. However, the results indicate that overall, lodgepole pine is the poorest, and ponderosa pine is the best, of the four hosts for mountain pine beetles.

582. AMMAN, G.D., BAKER, B.H., STIPE, L.E. Lodgepole pine losses to mountain pine beetle related to elevation.
US For. Serv. Research Note, INT-171, 1973: 1-8
Subject Codes: N/A
BIO: 74049573

583. AMMAN, G.D., COLE, W.E. 1983. Mountain pine beetle dynamics in lodgepole pine forests. Part II: population dynamics. General Technical Report, Intermountain Forest and Range Experimental Station, USDA Forest Service. 59 p.

Partly original work and partly a review of Dendroctonus ponderosae taxonomy, biology, behaviour, survival and mortality and host influences. Pinus contorta characteristics such as size and phloem thickness have a strong influence on beetle survival, size, sex ratio, and genotype. Of the many mortality factors acting on the beetle population alone or in combination, none regulate the population before severe damage occurs to stands of lodgepole pine, demonstrating that the mountain pine beetle is food regulated.

584. AMMAN, G.D., MCGREGOR, M.D., CAHILL, D.B., KLEIN, W.H. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains.
US For. Serv. Gen. Tech. Rep., 1977, INT-36: 19 pp.
Subject Codes: N/A
BIO: 77097784

585. AMMAN, G.D., PACE, V.E. Optimum egg gallery densities for the mountain pine beetle in relation to lodgepole pine phloem thickness.
USDA For. Serv. Res. Note, Intermountain For. and Range Exp. Stn., 1976, No. INT-209: 8 pp.
21 ref.
Subject Codes: 1.2, 1.3
CAB: 878457

Optimum densities of egg galleries of Dendroctonus ponderosae in Pinus contorta var. latifolia phloem of different thickness were studied in the laboratory. Maximum beetle production per 30 cm2 of bark occurred at egg-gallery densities of about 2.1 m and 2.4 m per 30 cm2 in thin and thick phloem respectively, and beetle production was greater in thick phloem. The smaller size of beetles, and lower survival of males, that emerged from the phloem suggest a qualitative difference between thin and thick phloem that may be important in the population dynamics of D. ponderosae.

586. AMMAN, G.D., RASMUSSEN, L.A. A comparison of radiographic and bark removal methods for sampling of mountain pine beetle populations.
USDA For. Serv. Res. Paper, Intermountain For. and Range Exp. Stn., 1974, No. INT-151: 11 pp.
10 ref.
Subject Codes: N/A
CAB: 409528

Estimates of numbers of live larvae of Dendroctonus ponderosae in standing Pinus contorta by both radiographic and bark-removal methods were comparable. The radiographic method, however, is more costly, does not usually make it possible to determine causes of beetle mortality, has adverse effects on the beetle populations (leading to erroneous estimates of brood survival and distorted sex ratios), and is not recommended for field sampling.

587. AMMAN, G.D., SAFRANYIK, L. 1985. Insects of lodgepole pine: impacts and control. Pages 107-124. in Lodgepole pine: the species and its management Symposium proceedings. Washington State University, Pullman, WA.

Of approximately 240 species of insects that feed on lodgepole pine, 35 are considered pests or potential pests. Nine insect species cause serious damage in periodic, local infestations and one species, the mountain pine beetle, causes catastrophic losses in repeated outbreaks over most of its distributional range. Stand management offers the best possibility for reducing losses. Seed and cone insects do not extensively affect seed production; nursery stock can be protected through cultural practices and pesticide treatments. Several insects affecting young stands cause reduced height growth and permanent crooks in stems. Defoliating insects, such as the lodgepole needle miner and pine sawflies, usually infest trees of all ages and cause growth loss and some mortality during severe outbreaks. Bark beetles, especially the mountain pine beetle, pose the most serious threat to lodgepole pine management.

588. ANNILA, E. The biology of Pissodes validirostris Gyll. (Col., Curculionidae) and its harmfulness, especially in Scots pine seed orchards.
Metsantutkimuslaitoksen Julkaisuja, 1975, 85(6): 95 pp.
168 ref.
Language: en
Summary Languages: fi
Subject Codes: N/A
CAB: 915046

In southern Finland, 20% of cones in seed orchards of Pinus sylvestris were infested by P. validirostris. About 75% of cones of P. contorta were also infested. It is suggested that damage in pine seed orchards can be reduced by establishing seed orchards on relatively large, flat fields, by using grafts of N. Finnish clones in central but not S. Finland, by keeping orchards and their surroundings clear of P. contorta, and by collecting and removing infested cones every autumn in central Finland (where they contain overwintering weevil larvae) but leaving them in situ in S. Finland (where they contain overwintering parasites but the unparasitized weevils have left).

589. ANNILA, E. Control of the pine cone weevil, Pissodes validirostris Gyll.

(Coleoptera: Curculionidae) in pine seed orchards.
Commun. Inst. For. Fenn., 1977, 90(6): 1-14
Subject Coes: 2.8
LISC: 434715

Possible practical methods for reducing P. validirostris damage in Pinus contorta were investigated to determine if the insecticides used have any phytotoxic effects on the quality and quantity of the future seed crop of P. sylvestris. It was concluded that damage can easily be controlled by spraying the base of the trees or grafts twice a year with an insecticide which has a relatively long-term effect.

590. ANNILA, E. The life-cycles of the cone-infesting dioryctria species (Lepidoptera, Pyralidae) in Finland.
Notulae Entomologicae, 1979, 59(2): 69-74
15 ref.
Language: en
Summary Languages: fi, sv
Subject Codes: N/A
CAB: 1316065

The potential damage to conifers is reviewed for 4 species that infest cones (and sometimes shoots and bark), and results are given of rearings of these species from cones of (a) Norway spruce, (b) Scots pine and (c) Pinus contorta var. latifolia collected from 5 localities in 1970-72; D. abietella and D. schuetzeella were found in (a) and D. mutatella in (b) and (c). Most of the larvae of D. mutatella were found in cones earlier infested by Pissodes validirostris.

591. ANNILA, E., et al. Entomology. Congress Group 6. IN: Proceedings Div. II, Forest Plants and Forest Protection XVI IUFRO World Congress, Oslo, Norway, June 20 - July 2, 1976.
As, Norway; IUFRO, 1976: 362-466
Language: en, de
Summary Languages: de, fr
Subject Codes: N/A
CAB: 878138

Many articles by various authors including: Annila, E. Cone and seed insect problems in seed orchards in Europe. Baltensweiler, W. Insect population dynamics. Vite, J.P. The fundamental bases for integrated pest management: ecosystem interactions. Varley, G.C. Research in pest population dynamics. Khlebopros, R.G. Inertial and inertialess mechanisms for quantity regulation of forest insects. Safranyik, L. Climatic barriers and influences on integrated control of Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae) in western Canada on Pinus contorta. Amman, G.D. Integrated control of the mountain pine beetle in lodgepole pine forests. Schonherr, J. Mountain pine beetle: visual behaviour related to integrated control. Cole, W.E. Mathematical models for the mountain pine bark beetle populations.

592. ANNILA, E., HILTUNEN, R. Damage by Pissodes validirostris (Coleptera, Curculionidae) studied in relation to monoterpene composition in Scots pine and lodgepole pine.
Annales Entomologici Fennici, 1977, 43(3): 87-92
18 ref.
Subject Codes: 1.2, 2.8
CAB: 1022660

Differences were found between the injuriousness of Pissodes validirostris to cones of (a) Pinus sylvestris and (b) P. contorta, and to different clones of P. sylvestris in forest seed orchards in southern Finland. The percent infestation was much higher for (b) than for (a); cones of P. banksiana were not attacked. The most abundant monoterpene in (a) was alpha-pinene, and there was a negative correlation with the intensity of damage. A positive correlation was found between the number of infested cones and the foliage content of myrcene, 3-carene, beta-phellandrene and p-cymene. In (b), beta- phellandrene and beta-pinene predominated and in P. banksiana, alpha and beta-pinene predominated. Factors conferring resistance to insect attack are discussed.

593. AUSTARA, O. Survey of the pine beauty moth Panolis-flammea new-record in Norway

in 1980 and 1981 using traps with synthetic pheromone analogs.
Fauna Nov. Ser. B, 1982, 29(2): 105-109
Subject Codes: N/A
BIO: 75050024

P. flammea (Denis et Schiffermuller) was recorded from 25 localities of a total of 36 localities surveyed in 1980 and 1981 using traps with synthetic pheromone analogs. The northern distribution was extended from Kvamme in More and Romsdal province to Namsos in Sor-Trondelag. In south Norway the moth was recorded from several localities further inland compared to previously known records and from several new localities along the west coast. The survey is a part of the internordic project, pests of Pinus contorta. In the nordic countries P. flammea has never been reported as a pest of Pinus contorta Douglas, but because of heavy infestations in P. contorta plantations in Scotland (UK), during the later half of the 1970's, it was decided to obtain more information about the distribution of the moth in Norway.

594. BAKER, B.H., AMMAN, G.D., TROSTLE, G.C. Does the mountain pine beetle change hosts in mixed lodgepole and whitebark pine stands?
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1971, No. INT-151: 7 pp.
6 ref.
Subject Codes: N/A
CAB: 083857

Losses of Pinus contorta and P. albicaulis attributable to Dendroctonus ponderosae were compared in three study areas within two stands composed of the two pines in mixture with Picea engelmannii at 8 700-10 200' alt. in the Teton and Bridger National Forests (W. Wyoming). There was a significant different in mortality between the pine species in each stand, but no overall preference was shown for either species. It is concluded that D. ponderosae displays host specificity for the species in which it has completed larval development.

595. BEJER, B. Insect risks for introduced and native conifers in Northern Europe, especially in the Nordic countries.
Bulletin, Organisation Europeenne et Mediterraneenne pour la Protection des Plantes, 1981, 11(3): 183-185
Language: en
Summary Languages: fr, ru
Subject Codes: 3.0
CAB: 1523965

The geographical origins and "niches" of exotic insects attacking native and exotic conifers in Scandinavia are discussed. Those insects attacking seeds and foliage have spread most easily; these include aphids of the Adelges group, such as A. nordmannianae (Eckstein) (Dreyfusia nordmannianae) attacking silver fir (Abies alba), and sawflies (Tenthredinidae) and small Lepidoptera on European larch (Larix decidua). Insects associated with bark and timber have been imported by trade routes only. The exotic conifer species are attacked mainly by native insects: these include spruce (Picea in Denmark, attacked by Dendroctonus micans (Kug.) and Elatobium abietinum (Wlk.) (Liosomaphis abietina), and lodgepole pine (Pinus contorta), attacked by numerous indigenous species including Ips typographus (L.) in Denmark, and by Pityogenes chalcographus (L.) in Sweden.

596. BERRYMAN, A.A. Interactions between bark beetles & pathogens & their influence on forest productivity.
Project WNP00052, Washington State Univ., Pullman, WA, 01 Jul 70 to 30 Sep 86
Subject Codes: N/A
CRIS: 0057480

Objectives: Determine the role of bark insects in the transmission and inoculation of decay fungi and other microorganisms. Determine the behavioral, physiological and biochemical mechanisms involved in the host selection and, colonization behavior of bark beetles and their associated fauna and flora. Develop test survey methods and treatment tactics. Approach: Experimental procedures will involve caging trees and introducing known numbers of beetles, gas chromatography, masspectrometer and bomb calorimeter analysis of conifer tissues before and after attack by the beetle, or inoculation by the symbiotic fungi, evaluating the effect of natural and artificial stress on conifer energy reserves and defense abilities, critical analysis of trees surviving beetle attack. Progress: The relationship between the vigor index proposed by Waring and Pitman,

as expressed by stemwood growth per m(-2) of crown area estimated by sapwood basal area, was tested in 1981. Increment cores were taken from 100 lodgepole pines in infested stands near West Glacier and Hungry Horse, MT. Each tree was inoculated with the pathogen, Europhium clavigerum, and the resulting wound response sampled. Primary resin flow and tree characteristics were also measured (i.e., DBH, crown conditions, etc.). Selected trees were belted with pheromone and beetle attacks monitored over time along with resin flow rates and phloem wound respones. Preliminary analysis indicates that all stands sampled were in the low vigor classes determined by Waring and Pitman. Surprisingly no correlations were found between tree vigor rating and beetle attack parameters but vigor ratings were useful for establishing thresholds of mortality in attacked trees. chemical analysis of wound reaction tissue and resin will be carried out over the winter months.

597. BERRYMAN, A.A. Management of mountain pine beetle populations in lodgepole pine ecosystems: a cooperative, interdisciplinary research and development project.
IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Services, 1973, pub. 1975: 627-650
Subject Codes: N/A
CAB: 757693

The objectives, organization, participating institutions, and scientists of a cooperative research project, aimed at developing a pest management system for Dendroctonus ponderosae in Pinus contorta stands, are presented. The conceptual framework on which the management system is being built is discussed in relation to: measurement, description and modelling of the dynamic insect population; description and analysis of the socioeconomic impact of the insect on the forest resource; analysis and decision- making procedures for optimizing management alternatives. Author's summary.

598. BERRYMAN, A.A. Theoretical explanation of mountain pine beetle dynamics in lodgepole pine forests.
Environ. Entomol., 1976, 5(6): 1225-1233
Subject Codes: N/A
BIO: 63019916

Sample data from 215 infested lodgepole pines (Pinus contorta var. latifolia) from 11 separate locations in the USA and Canada were analyzed to determine the relative effect of the measured variables on mountain pine beetle (Dendroctonus ponderosae) emergence density (production). From this analysis a model was developed which expresses production as a function of attack density and basic habitat suitability. The measured variables having the most influence on basic habitat suitability were lodgepole pine phloem thickness, cortical resin canals, host resistance and predation by woodpeckers. Host resistance was also found to influence the intensity of attack. A theoretical model was constructed to examine the relative effects of lodgepole pine phloem thickness, and resistance to attack, on the dynamics of the beetle population. Analysis indicated that mountain pine beetle outbreaks are triggered by rapid declines in stand resistance resulting from climatic disturbances, insect defoliation, etc.

599. BERRYMAN, A.A. Mountain pine beetle outbreaks in Rocky Mountain lodgepole pine forests.
Journal of Forestry, 1982, 80(7): 410-413, 419
37 ref.
Subject Codes: N/A
CAB: 1557106

A discussion of the causes of Dendroctonus ponderosae outbreaks and methods of anticipating and preventing them, based on recent research. It is suggested that outbreaks occur when stand vigour (measured by various growth data) declines below a critical threshold but a high proportion of trees still have thick phloem. Once started, an outbreak can spread over vast areas because large beetle populations can overcome relatively resistant trees. From author's summary.

600. BERRYMAN, A.A. Physiological and chemical changes in lodgepole pines subjected to stress from bark beetle attack.
Project 82(WNPC0606), Washington State Univ., Pullman, WA, 15 Aug 82 to 31 Aug 84
Subject Codes: N/A
CRIS: 0033942

Objectives: By means of screening healthy lodgepole pine against natural bark beetle attack, densities of infesting beetles will be regulated to elicit the maximum resistance response from the tree. Densities of attacking beetles will be regulated by introducing previously captured beetles onto screened trees at predetermined rates. Approach: Physiological changes in these attacked trees will be monitored by sequential sampling of phloem and wound responses and the subsquent analysis of these samples for monoterpene and carbohydrate content and composition.

601. BERRYMAN, A.A., RAFFA, K.F., MILLER, R.H. Conifer resistance to bark beetle - fungal complexes.
Project 7800861(WNP00441), Washington State Univ., Pullman, WA, 01 Sep 78 to 31 Mar 81
Subject Codes: 6.2
CRIS: 0033202

Objectives: Bark beetles are the most destructive group of forest insects, and are annually responsible for the loss of several billion board feet of timber. Although there are currently no satisfactory means of control, among the most promising are the development of management strategies based on the accurate prediction of bark beetle epidemics, and the development of resistant trees through either genetic or silvicultural means. To develop these methods, it is first necessary to develop an understanding of the mechanisms of tree resistance to bark beetles and the influence of environmental stress on these processes. Approach: Examine the nature of predisposition to bark beetle attack in terms of the influence of host resistance on the key stages of the attack sequence (initial entry, aggregation, and attack cessation), the host factors associated with the various behavioral responses exhibited by the beetles during this interaction, and physiological differences between resistant and susceptible trees. Progress: (80/01 81/01) Lodgepole pines were examined for a series of chemical and physiological traits prior to their exposure to natural mountain pine beetle attacks. The major difference between resistant and susceptible trees was the greater quantity of monoterpenes produced by the former. The dynamic induction of the wound response, rather than any constitutive traits, serves as the main means of defense to bark beetle-fungal infection. Extracts from the outer bark of resistant and susceptible trees were applied to paper tissues and exposed to female beetles. Both benzene and methanol-water extracts induced greater feeding than controls. Non-polar host compounds had greater incitant (induction of feeding) and weaker stimulant (continuation of feeding) properties than polar constituents. Feeding was equal on resistant and susceptible trees. Whole-bark assays from the same trees indicated that the repellent properties of resistant trees may be associated with active metabolism. A series of field experiments were conducted to examine the relationship between attack density, tree mortality, beetle reproductive success and beetle behavior. All trees were able to resist attack below a critical threshold (40/m2). Optimal reproduction occurred at the attack density (62/m2) where the combined detrimental effects of host resistance and crowding were smallest. The aggregation behavior of the mountain pine beetle is cloely linked to the physiological state of its host.

602. BERRYMAN, A.A., SAFRANYIK, L. (Editors) Mountain pine beetle response to lodgepole pine stands of different characteristics. IN: Proceedings of the 2nd IUFRO Conference on Dispersal of Forest Insects: Evaluation, Theory and Management Implications.
Pullman, Washington, USA; Washington State University, 1980: 234-243
9 ref. 1 pl.
Subject Codes: N/A
CAB: 1487586

Flying Dendroctonus ponderosae were trapped using passive non-directional barrier traps at 1.8 m, mid-bole and mid-crown in thinned and unthinned Pinus contorta stands in Montana and Wyoming. Of 488 beetles caught, 48% were at mid-bole, 35% at 1.8 m and 17% at mid-crown. More females than males were caught at all heights. Beetles were caught with equal frequency in thinned and unthinned stands but more trees were attacked in thinned stands. From authors' summary.

603. BERRYMAN, A.A., SAFRANYIK, L. (Editors). Effect of weather on activity and movement of lodgepole pole needle miner moths.
Pullman, Washington, USA, Washington State Uniersity, 1980: 143-152
9 ref., 1 pl.

Language: en
Summary Languages: fr
Subject Codes: 6.4
CAB: 1487580

In a study in Banff National Park, Alberta, Canada, numbers of adult Coleotechnites starki caught each hour by rotating nets at the top of Pinus contorta trees were correlated with environmental factors. Females were active from 19.30 to 21.30 hr. when temp. was above 11 deg. C; males were active from 21.00 hr. throughout the night when temp. was above 9 deg. C. Rain sufficient to wet the foliage or winds over 1.2 m/s caused activity to cease.

604. BERRYMAN, A.A., STARK, R.W. 1985. Assessing the risk of lodgepole pine stand destruction by pests. Pages 163-169 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Destructive outbreaks of forest pests are classified as gradient, cyclical or eruptive. The first two types of outbreaks (gradient, cyclical) are generated by stand and site conditions conducive to the reproduction and survival of the pest or stressful for the host plant(s). In these cases, outbreak probability, or risk, can be assessed with unidimensional risk equations. (outbreaks of the third type, the eruptive pests, are more difficult to predict because the density of the pest plays a critical role in initiating outbreaks in particular stands. Risk assessment models for these pests require a two-dimensional structure that integrates stand, site and insect numbers. We discuss methods for developing risk assessment models for eruptive pests using, as an example, mountain pine beetle populations infesting lodgepole pine stands.

605. BORDEN, J.H., CHONG, L.J., LACEY, T.E. 1986. Pre-logging baiting with semiochemicals for the mountain pine beetle, Dendroctonus ponderosae, in high hazard stands of lodgepole pine. Forestry Chronicle. 62(1):20-23.

In studies in interior British Columbia, 155 lodgepole pines in 3 blocks were baited with myrcene, transverbenol and exo-brevicomin. The eastern boundary of each block faced the upper edge of a ravine (0-100 m distant) and the nearest infestations of mountain pine beetles were 75-200 m east of the blocks. A total of 96 baited trees were attccked, of which 63 were mass attacked. Trees surrounding 50 of the baited trees were infested, accounting for 83.15 of the 533 newly-infested trees. Baiting was thus effective in concentrating the attack. There was some evidence of containment and shifting of infestation loci as a result of the baiting programme. Baits were ineffective when applied in the understorey and also failed to draw a massive influx of beetles from the infestations 75-200 m away. Baiting is cost effective if enough beetles are contained within or attracted to a baited block to avoid the necessity to dispose of 2 trees/ha outside the block. The risk of future infestations is reduced by removing beetles and their broods during logging of induced infestations.

606. BORDEN, J.H., LACEY, T.E. 1985. Semiochemical-based manipulation of the mountain pine beetle, Dendroctonus ponderosae Hopkins: a component of lodgepole pine silviculture in the Merritt timber supply area of British Columbia. Zeitschrift fur Angewandte Entomologie. 99(2):139-145.

The Merritt timber supply area in south-central British Columbia is taken as an example of a forest management unit in which large areas of mature and over-mature lodgepole pine (Pinus contorta var. latifolia) are vulnerable to infestation by Dendroctonus ponderosae. Seventeen sites are described in which 2132 semiochemical baits containing myrcent (7-methyl-3- methylene-1, 6-octadiene), trans-verbenol ((1alpha,2alpha,5alpha)-4,6,6- trimethylbicyclo (3.3.3)hept-3-en-2ol) and exo-brevicomin (exo-7-ethyl-5- methyl-6,8-dioxabicyclo(3.3.3)octane) were used in 1984 as a component of forest management operations to manipulate populations of D. ponderosae. The principal applications of the semiochemical baits were to contain and concentrate infestations on baited trees prior to logging, and to 'mop up' remaining beetles in post-logging treatments.

607. BURNELL, D.G. A dispersal aggregation model for mountain pine beetle in lodgepole pine stands.
Res. Popul. Ecol. (Kyoto), 1977, 19(1): 99-106
Subject Codes: N/A
BIO: 65051692

A dispersal-attack theory for bark beetle attacking trees is developed from a set of simple assumptions, and the resulting theoretical model is fit to data from 4 epidemic studies. Implications of the theory are discussed in relation to the dynamics of lodgepole pine-mountain pine beetle interactions.

608. CEREZKE, H.F. A method for estimating abundance of the weevil Mylobius-warreni and its damage in lodgepole pine stands.
Forest Chron., 1970, 46(5): 392-396
Subject Codes: N/A
BIO: 52036438

609. CEREZKE, H.F. Effects of weevil feeding on resin duct density and radial increment in lodgepole pine.
Can. J. For. Res., 1972, 2(1): 11-15
Subject Codes: 5.1
BIO: 54030842

610. CEREZKE, H.F. Survival of the weevil, Hylobius warreni Wood, in lodgepole pine stumps.
Canadian Journal of Forest Research, 1973, 3(3): 367-372
9 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 351924

Reports a study of the occurrence of H. warreni in stumps of Pinus contorta var. latifolia on a clear-felled area near Robb, Alberta, between 1961 and 1965. Larvae continued to develop in the stumps for 2 years after tree removal, although

larval mortality during this period was ca. 88%. No larvae were found in the third year. In the fourth year after felling, an increase in weevil abundance occurred in adjacent standing trees. Numbers of newly developed adults were significantly greater in the felled areas, compared with adjacent unfelled areas, in the second year after felling; the increase was attributed to the occurrence of higher temperatures, as a result of felling, in the larval feeding zone of the stumps. Recommendations are made for the use of clear felling as a method for weevil control.

611. CEREZKE, H.F. Bark thickness and bark resin cavities on young lodgepole pine in relation to Hylobius warreni Wood (Coleoptera: Cuculionidae).
Canadian Journal of Forest Research, 1973, 3(4): 599-601
8 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.4
CAB: 267079

Some patterns of bark thickness and characteristics of bark resin-cavities in 20 to 25 year-old Pinus contorta var. latifolia are described in relation to the zone of oviposition and larval feeding by H. warreni. The resin-cavity characteristics studied were size, density per mm2 of bark cross-section, and area as a % of the cross-sectional area of bark on lateral roots, root-collar and lower stem. The zone of oviposition and larval feeding was found to occur where the bark was at its maximum thickness but where the cavities were at a low density and the area that they occupied in the bark was small.

612. CEREZKE, H.F. Some parasites and predators of Hylobius warreni in Alberta.
Bi-monthly Research Notes, 1973, 29(4): 24-25
Subject Codes: 6.2
CAB: 235079

A study in semi-mature forests of Pinus contorta var. latifolia showed that several organisms caused considerable mortality of H. warreni or are suspected of contributing to mortality or to reduced fecundity. These included a wasp (Dolichomitus tuberculatus), a number of nematodes, mites (Hericia spp.), and the

entomogenous fungus Beauveria bassiana.

613. CEREZKE, H.F. Effects of partial girdling on growth in lodgepole pine with application to damage by the weevil Hylobius warreni Wood.
Canadian Journal of Forest Research, 1974, 4(3): 312-320
19 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 409523

Leader growth and radial increment on the stem and main lateral roots during three consecutive years after partial girdling treatments were analyzed on 25-to-30-year-old trees of Pinus contorta var. latifolia from a natural stand in W. -central Alberta. The treatments, made to simulate wounds caused by larval feeding of Hylobius warreni, consisted of the removal of a band of bark 7 mm wide from 0% (control), 20%, 40%, 60%, 80% and 90% of the root-collar circumference of 58 sample trees. Partial girdling reduced leader elongation and radial increment of the leader and lateral roots. Leader height decreased with increased girdling of the root-collar during each of the three years after treatment. Below the leader, partial girdling of the root-collar did not affect radial increment in the first year but caused an increase during the second year and a decrease in the third year. At 2 cm above the partial girdles, radial growth above the girdled side of the stem was always less than on the other side and tended to increase with increasing severity of girdling on lateral roots extending below girdle wounds during the three post-treatment years. Two graphs that can be used to estimate height and radial increment losses in young pine stands infested by H. warreni are presented.

614. CIESLA, W.M. Observations on the life history and habits of a pine sawfly Neodiprion-nanulus-contortae hymentoptera diprionidae.
Ann. Entomol. Soc. Am., 1976, 69(3): 391-394
Subject Codes: N/A
BIO: 62025028

Observations on the biology and ecology of N. n. contortae Ross in NW Montana are reported. This sawfly is known from Oregon, Idaho and Montana, USA and Alberta, Canada where it feeds on lodgepole (Pinus contorta Douglas) and ponderosa pine (P. ponderosa Lawson). N. n. contortae occasionally reaches epidemic levels causing significant defoliation. Seasonal history is similar to that described for N. n. nanulus in Wisconsin. There is 1 generation/year with winter being passed in the egg stage. Larvae feed in June and early July on older needles. Adult emergence occurs from mid-Sept. - mid-Oct. Notes on occurrence of outbreaks, natural enemies and effect on hosts are presented.

615. COLE, W.E. Population dynamics of mountain pine beetle.
Project INT-2201, Intermountain For. and Range Exp. Sta., Ogden, UTA, 08 Mar 66 to Sep 84
Subject Codes: N/A
CRIS: 0000202

Objectives: Develop understanding of the dynamics of the mountain pine beetle endemic populations in both managed and unmanaged lodgepole pine; develop understanding of the population dynamics of the mountain pine beetle in ponderosa pine stands with high annual mortality. Develop management strategies for the prevention and/or minimization of tree losses due to the mountain pine beetle; model mountain pine beetle populations in lodgepole and ponderosa pines under endemic and epidemic conditions, varying forest conditions, and management situations. Approach: 1) Sampling methods will be developed to evaluate spatial and temporal relations of endemic mountain pine beetle populations and identify conditions most conducive to epidemic population development. 2) Similar studies will be done on mountain pine beetle populations in ponderosa pine. 3) Various management strategies will be tested, based on knowledge gained from (1) and (2) to minimize and/or prevent tree losses. Experiments now underway in lodgepole pine will be continued. 4) Data and information gained from (1), (2), and (3) will be used to construct empirical models of these situations for basis of decision-making and cost/benefit analyses. Progress: 80/10 81/09 During the first year of research effort on factors that trigger outbreaks and/or maintain mountain pine beetle populations at tolerable levels, a passive trapping system for flying beetles was developed and is now being correlated with managed and

unmanaged stands of lodgepole pine. The role of secondary bark beetles in maintaining low populations of beetles and/or predisposing trees to allow the beetle population to increase is being researched. Evidence to date strengthens the suspicion that secondaries play a major role in the endemic population maintenance. The wide range in response of the mountain pine beetle to ponderosa pine stands suggests that the beetle may be responding to differences in microclimatic factors associated with stand development and characteristics, and a variety of biological and population factors. Beetle flight through these stands is being monitored and related to stand conditions and characteristics of trees being attacked. Phloem moisture, as affected by blue-stain fungi, appears to be important to beetle survival. Harvesting strategies developed from research have been applied on 6 national forests; 4 in lodgepole pine and 2 in ponderosa pine stands. All lodgepole pine areas cut show little if any reinfestation. The 2 ponderosa pine cuts are too new for any evaluation as yet. A cost-benefit study is underway for the economics at this time, but will be expanded to include other forest resources than timber.

616. COLE, W.E. The statistical and biological implications of sampling units for mountain pine beetle populations in lodgepole pine.
Res. Pop. Ecol. (Kyoto), 1970, 12(2): 243-248
Subject Codes: N/A
BIO: 52089065

617. COLE, W.E. Interaction between mountain pine beetle and dynamics of lodgepole pine stands.
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1973, No. INT-170: 6 pp.
6 ref.
Subject Codes: N/A
CAB: 257633

Summarizes the results of a series of studies, in the Intermountain area, on the infestation of Pinus contorta stands by Dendroctonus ponderosae, with emphasis on the influence of site and stand factors on beetle populations, and of beetle populations on stand dynamics. Factors that influenced the populations of beetles were (1) the type of habitat within which P. contorta grew, (2) the altitude of the stand, (3) the tree diameter, and (4) the thickness of phloem.

618. COLE, W.E. Interpreting some mortality factor interactions within mountain pine beetle broods.
Environ. Entomol., 1975, 4(1): 97-102
Subject Codes: N/A
BIO: 59060096

619. COLE, W.E., AMMAN, G.D. Mountain pine beetle infestations in relation to lodgepole pine diameters.
US Forest Serv. Research Note, 1969, INT-95: 1-7
Subject Codes: N/A
BIO: 69082748

620. COLE, W.E., AMMAN, G.D. Mountain pine beetle dynamics in lodgepole pine forests. Part I: Course of an infestation.
Gen. Tech. Rep., Intermountain For. and Range Exp. Stn., USDA For. Service, 1980, No. INT-89: 56 pp.
many ref., 1 pl.
Subject Codes: N/A
CAB: 1455823

A review of the literature on epidemic infestations of Dendroctonus ponderosae in lodgepole pine forests, including some previously unpublished research by the authors. The form of epidemics is discussed with reference to habitat type, altitude, tree size and phloem thickness. Methods of determining stand susceptibility are described. Management alternatives are reviewed in relation to: mixed age/species stands; rotation time; stocking control; felling and thinning practices; and chemical control. An example is given of management planning for alleviating pine beetle damage in an Oregon forest.

621. COLE, W.E., AMMAN, G.D., JENSEN, C.E. Mathematical models for the mountain pine beetle lodgepole pine interaction.
Environ. Entomol., 1976, 5(1): 11-19
Subject Codes: N/A
BIO: 61059870

622. COLE, W.E., CAHILL, D.B. Cutting strategies can reduce probabilities of mountain pine beetle epidemics in lodgepole pine.
Journal of Forestry, 1976, 74(5): 294-297
6 ref.
Subject Codes: 7.5
CAB: 662847

Reports on a sample survey of phloem thickness as related to stem diameter and beetle infestation in three areas in Colorado where oubreaks of Dendroctonus ponderosae on Pinus contorta had reached different stages. Felling prescriptions designed to reduce the epidemic potential of the beetle (by limiting the residual food supplies in the phloem) in the Intermountain and Rocky Mountain areas of the USA are discussed. Results showed that partial felling to prevent trees from reaching a d.b.h. of 10" would significantly reduce the probability of epidemic development in most cases.

623. COLE, W.E., GUYMON, E.P., JENSEN, C.E. Monoterpenes of lodgepole pine phloem as related to mountain pine beetles.
Research Paper, Intermountain For. and Range Exp. Stn., USDA For. Service, 1981, No. INT-281: 10 pp.
18 ref.
Subject Codes: 1.2
CAB: 1514872

Phloem samples were taken in 1975 from 86 healthy trees in Cache National Forest, Utah, and analyzed for content of DM, starch, various forms of sugar and N. and selected monoterpenes, beta-Phellandrene was much the commonest monoterpene. An interactive hypothesis is developed for monoterpene content as a function of phloem thickness and tree diam.: it appears that the highest concn. of monoterpenes are found in the larger trees (9-20" dbh), where Dendroctonus ponderosae survival is best.

624. COTTRELL, C.B., UNGER, L.S., FIDDICK, R.L. Timber killed by insects in British Columbia, 1971-1975.
Victoria, 8ritish Columbia, Pacific Forest Research Centre, 1979: 31 pp.
5 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1355065

Data are presented on the numbers of trees killed in British Columbia in 1971-75 by Dendroctonus ponderosae Hopk. on lodgepole pine (Pinus contorta), western white pine (P. monticola) and ponderosa pine (P. ponderosa); D; rufipennis (Kby.) on Engelmann spruce (Picea engelmanni); Dryocoetes confusus Sw. (in association with the fungus Ceratocystis dryocoetidis) on alpine fir (Abies lasiocarpa); Orgyia pseudotsugata (McDunn.) on Douglas fir: Lambdina fiscellaria lugubrosa (Huist) on western hemlock (Tsuga heterophylla) and amabilis fir (A. amabilis); and Nepytia freemani Munroe on Douglas fir. Scolytids continued as the major cause of tree mortality. The total volume of timber killed decreased markedly, especially in stands of spruce and alpine fir. However, increased mortality occurred in pine stands throughout the interior of the province. Defoliating insects caused tree mortality in localized areas of the Kamloops and Vancouver Forest regions.

625. COULSON, R.N. Population dynamics of bark beetles.
Annual Reviews of Entomology, 1979, Vol. 24, VII+579 pp: 417-447
Subject Codes: N/A
8IO: 17018716

626. COULSON, R.N., LEUSCHNER, W.A., et al. Approach to research and forest management for southern pine beetle (Dendroctonus-frontalis) control.
Environmental Science and Technology, New Technology of Pest Control, XVI+500 pp, John Wiley & Sons, N.Y., N.Y., USA, 1980, 0(0): 449-470
Subject Codes: N/A
BIO: 19023746

627. CROOKSTON, N.L., STARK, R.W., ADAMS, D.L. Outbreaks of mountain pine beetle in lodgepole pine forests - 1945 - 1975.
Bulletin, Forest, Wildlife and Range Exp. Stn., Univ. of Idaho, 1977, No. 22: 7 pp.
74 ref., 1 map
Subject Codes: N/A
CAB: 1216529

Outbreaks of mountain pine beetle (Dendroctonus ponderosae) in the western USA are mapped over this period and provide an indication of general hazard zones. The intervals between infestations at selected locations from 1910 to 1975 are tabulated and varied between 6 and 64 yr; controlling factors are thought to include av. phloem thickness, age, b.a. and site characteristics.

628. DAHL, B.M. Mortality of Monochamus larvae in slash fires.
Can. Dep. Fish, For., Bi-monthly Research Notes, 1971, 27(2): 12 pp.
Subject Codes: N/A
BIO: 71069911

629. DATERMAN, G.E., CAROLIN, V.M. JR. Survival of European pine shoot moth, Rhyacionia buoliana (Lepidoptera: Olethreutidae), under caged conditions in a ponderosa pine forest.
Canadian Entomologist, 1973, 105(7): 929-940
22 ref.
CAB: 441419

Results of experiments in 1968 and 1969 showed that R. buoliana developed successfully in young, even-aged stands of Pinus contorta and P. ponderosa in central Oregon. P. contorta and slow-growing trees of P. ponderosa were most susceptible to damage. P. ponderosa trees 7 feet high appear resistant to damage because of their ability to sustain larval feeding activity without suffering stem distortion. Significantly higher egg mortality was consistently observed on drier study sites E. of the Cascades in Oregon than on sites W. of the Cascades in Washington, where the insect is an established pest of ornamentals. The major physical restraint on the spread of the insect appears to be mortality of overwintering larvae caused by low winter temperatures. Areas in the western pine zone having a high susceptibility to damage by R. buoliana appear to be southern Oregon and California north of 40 deg. N. lat.

630. DEYRUP, M.A., GARA, R.I. Insects associated with Scolytidae (Coleoptera) in western Washington.
Pan-Pacific Entomologist, 1978, 54(4): 270-282
29 ref.
Subject Codes: N/A
CAB: 1216523

Lists are given for 2 localities of some 25 scolytids and their associates on 3 species of conifer, viz. Douglas-fir, western hemlock and lodgepole pine. Factors influencing the species and number of associates (such as presence of alternative hosts/prey, exposure of tree to sunlight, bark thickness, etc.) are discussed.

631. DOMINIK, J. Results of 20 years' observations on the damage caused by insects to some exotic species of conifers in the experimental forests of the Agricultural University at Rogow.
Sylwan, 1972, 116(8): 11-18

8 ref.
Language: pl
Summary Languages: ru, en
Subject Codes: N/A
CAB: 098504

Lists the pests of Pinus contorta var. latifolia, P. Strobus, Picea pungens, P. sitchensis, Pseudotsuga menziesii, Tsuga canadensis, and Thuja plicata observed in these forests in Poland, and discusses their importance.

632. DOOM, D. On the development, damage, food plants and natural enemies of the pine bark-bug, Aradus cinnamomeus.
Nederlands Bosbow Tijdschrift, 1981, 53(4/5): 117-125
5 ref., 5 pl.
Language: nl
Summary Languages: en
Subject Codes: N/A
CAB: 1557087

A final report on a study in the Netherlands, parts of which have been published earlier. A. cinnamomeus was found on Scots, Austrian, Corsican and lodgepole pines and Larix leptolepis. No parasites of the bug were found. Several insect and spider predators responded in a density-dependent manner to the pest.

633. DYER, E.D.A., HALL, P.M. Timing cacodylic acid treatments to kill mountain pine beetles infesting lodgepole pine.
Bi-monthly Research Notes, 1979, 35(3): 13
3 ref.
Subject Codes: N/A
CAB: 1472669

Trunks of Pinus contorta were treated with cacodylic acid in Aug. and Sept.,

16-56 days after the main Dendroctonus ponderosae flight and attack. Bark samples showed n.s.d. in attack or brood density among treatments. Trees treated up to 3 weeks after initial attack showed 95-100% parent and brood mortality; treatment after 5 weeks produced no mortality in either parents or brood.

634. ENTWISTLE, P.F., EVANS, H.F., HARRAP, K.A., ROBERTSON, J.S. Field trials on the control of the pine sawfly, Neodiprion sertifier, using purified nuclear polyhedrosis virus.
Environmental Research Council, UK, 1978, No. 1: 62 pp.
Subject Coes: N/A
CAB: 1203498

Purified nuclear polyhedrosis virus (NPV) was sprayed at rates of 104, 105 and 106 polyhedral inclusion bodies per tree, using a Micron Mini-Ulva microdroplet machine in 8-yr-old lodgepole pine stands at Dumbarton Muir, near Glasgow, Scotland. Control of N. sertifer soon after hatching (31st May 1977) was good at the highest concn. with total mortality by 29 days after spraying. Other reported trials worldwide are briefly reviewed. Details of the NPV and its safety in use are given in appendices.

635. ESBJERG, P. Danish Hymenopterous and Dipterous parasites from Rhyacionia buoliana.
Entomologiske Meddelelser, 1972, 40: 9-20
Language: da
Summary Languages: en
Subject Codes: N/A
CAB: 114377

Tabulates data on distribution, parasitization rates, and population changes over 3 years for parasites obtained from Pinus contorta shoots from Danish plantations infested chiefly with R. buoliana (plus some R. pinicolana and Dioryctria abietella). It is concluded that the indigenous parasites cannot be used as a basis for biological control in Denmark and cannot prevent severe infestations, but that their reducing effect on populations is not negligible. It is suggested that parasite longevity and flying ability might be increased by establishing

umbelliferous flowers which, in Canada, serve as food for adults of the parasitic species.

636. EVANS, D. Establishment and survival of European pine shoot moth on container-grown 1-0 lodgepole pine.
Info. Report, Pacific For. Res. Centre, Canada, 1973, No. BC-X-79: 8 pp.
8 ref.
Subject Codes: N/A
CAB: 351531

Infestations of Rhyacionia buoliana were artifically established on first-year seedlings of Pinus contorta var. contorta and latifolia in a nursery in Victoria, British Columbia, from which a few adults emerged in the following season. It is concluded that there is a potential risk of transmitting R. buoliana with 1 + 0 nursery stock from coastal nurseries into interior areas that are at present free from the pest. Appropriate quarantine regulations have since been introduced.

637. EVANS, D. Pine shoot insects common in British Columbia.
Pacific Forest Research Centre, Victoria, B.C., 1982, BC-X-233: 56 pp.
19 ref.
Subject Codes: N/A
RCA: X1135

This publication is an aid to the identification of pine shoot insects on pines native to British Columbia. Eighty-five insect genera are referenced, including 75 species. The most important species are described, and keys to immature stages and their damage symptoms are presented; scientific, family and common names are given. Three major tree species are involved - one is divided into two varieties. Sixty-six colour photographs, a host distribution map, a glossary, references and an index are provided.

638. EVANS, H.J. Pine beauty moth - more Scottish forests at risk.
Q.J. For., 1979, 73(2): 109-110
Subject Codes: N/A
LISC: 423129

Some 3,400 ha of lodgepole pine plantations in 5 Scottish forests are seriously threatened by infestations of Panolis flammea (Lep., Noctuidae). The results of monitoring the effects of aerial spraying last year suggest that there were no serious effects on any section of the environment studied. No major mortalities occurred in species other than the primary target and sawfly larvae (Hym.) on the same trees. The decision has been taken to spray the threatened areas this year, although it is suggested that more detailed studies be made during future treatments to assess long-term effects.

639. FELLIN, D.G. Weevils attracted to thinned lodgepole pine stands in Montana.
USDA For. Serv. Research Paper, Intermountain For. and Range Exp. Stn., 1973, No. INT-136: 20 pp.
21 ref.
Subject Codes: N/A
CAB: 257629

Damage by Magdalis gentilis to thinned stands of Pinus contorta var. latifolia less than or equal to 11 years old was studied from 1965 to 1968. Adult weevils fed on needles of the current year's shoots, causing defoliation. Severe damage was confined to young trees in thinned areas and along the boundaries of adjacent unthinned areas. In the year of thinning, damage was severe on crop trees in areas thinned before late July, light where thinnings were completed only in Aug., and rare in areas thinned after mid-Aug. Slash was not used by the beetles, but it is suggested that volatile material from the slash attracted the adults to the thinned areas. It is concluded that M. gentilis is not a serious problem in P. contorta stands.

640. FERGUSON, D.C. Two new conifer feeding species of the genus Semiothisa lepidoptera geometridae.
Can. Entomol., 1972, 104(4): 563-565

Subject Codes: N/A
BIO: 54055280

641. GARA, R.I., LITTKE, W.R., AGEE, J.K., GEISZLER, D.R., STUART, J.D., DRIVER, C.H. 1985. Influence of fires, fungi and mountain pine beetles on development of a lodgepole pine forest in south-central Oregon. 1985. Pages 153-162 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Virtually pure lodgepole pine stands form an edaphic climax community over large areas of the infertile "pumice plateau" of south-central Oregon. During our ongoing studies on the dynamics of these forests we developed the scenario that periodic fires create fungal infection courts in damaged roots; in time, advanced decay develops in the butts and stems of these trees. The mountain pine beetle preferentially selects and kills these trees during the flight season. As these outbreaks develop, additional uninfected trees are attacked. In time, the stage is set for subsequent fires as needles drop, snags fall, and logs decay.

642. GEISZLER, D.R., GALLUCCI, V.F., GARA, R.I. Modeling the dynamics of mountain pine beetle aggregation in a lodgepole pine stand.
Oecologia, 1980, 46(2): 244-253
Subject Codes: N/A
LISC: 524171

A mathematical model was developed to: (1) describe Dendroctonus ponderosae (Col., Scolytidae) aggregation, (2) predict the relation of Pinus contorta susceptibility and switching to changes in beetle density, (3) provide a structure for current knowledge, and (4) pose questions for further research. The model indicates that a high population density ensures mass aggregation and consequently successful tree colonization and differs from tree to tree, possibly depending on resin quality and production and/or the local flying density of beetles. Field and model results indicate that tree size appears to affect the repellence of beetles, suggesting that the attack density or the visual attractiveness of large trees is a factor.

643. GIBSON, K.E., MCGREGOR, M.D. A review of selected mountain pine beetle (Dendroctonus ponderosae) epidemics (on lodgepole pine) and the infestation potential for the Tally Lake Ranger District, Flathead National Forest, Montana. Report, Northern Region, State and Private Forestry, USDA Forest Service, 1979, No. 79-5: 13 pp.
15 ref.
Subject Codes: N/A
CAB: 1500099

644. HALL, P.M., DYER, E.D.A., MCMULLAN, E.E. Foliar spray of acephate ineffective against mountain pine beetle in lodgepole pine.
Bi-monthly Research Notes, 1978, 34(6): 36
3 ref.
Subject Codes: N/A
CAB: 1286400

Acephate (1.12 or 5.6 kg/ha a.i.) was sprayed onto the foliage of 11 trees near Williams Lake, British Columbia, in July 1975, 3 days after infestation by Dendroctonus ponderosae. Three of the trees sprayed at the higher rate were resprayed after 14-18 days. Trees were felled at the end of Aug. Sample bolts from the butt and crown showed n.s.d. in beetle survival and development between any of the treatments or controls, and no trace of acephate was found in frozen samples.

645. HALL, R.J. compiler. Uses of remote sensing in forest pest damage appraisal. Northern Forest Research Centre, Edmonton, Alta., 1982, Information Report NOR-X-238
Subject Codes: 8.4
RCA: X1000

A seminar was held to review experiences and concerns in the application of remote sensing techniques to forest pest damage appraisal. Papers were presented on

detection and analysis of vegetative stresses; application of remote sensing to mountain pine beetle management in southern Alberta; practical applications of remote sensing for forest pest damage assessment; some recent developments in remote sensing at the Northern Forest Research Centre; the role, informational requirements, and pest problems of the Forest Insect and Disease Survey (FIDS), FIDS-related remote sensing studies in the Pacific region; and the uses of remote sensing in forest pest damage appraisal.

646. HAMEL, D.R., OAKES, R.D. Status of mountain pine beetle infestations in 2nd growth ponderosa pine stands: Little Belt and Big Snowy Mountains, Lewis and Clark National Forest, Montana, USA, 1976.
For. Environ. Prot., US For. Serv. North Reg., 1977, 77-14: 5 pp.
Subject Codes: N/A
BIO: 77068568

647. HAMEL, D.R., OAKES, R.D., HOTHEM, R. Potential for infestation by mountain pine beetle in lodgepole pine stands: Hungry-Horse District, Flathead National Forest, 1977.
For. Environ. Prot. US For. Serv. North Reg., 1977, 77-11: 5 pp.
Subject Codes: N/A
BIO: 77067652

648. HARRIS, J.W.E., DAWSON, A.F., BROWN, R.G. Detecting windthrow, potential foci for bark beetle (Dendroctonus rufipennis) infestation, by simple aerial photographic techniques.
Pac. For. Res. Centre, Victoria, B.C. Canada, Bi-monthly Research Notes, 1978, 34(5): 29
Subject Codes: 8.4
CAB: 1118769

In a mature white spruce/alpine fir/lodgepole pine stand in British Columbia, 13 trees were felled to simulate windthrow of isolated single trees. Photography before and after was at scales of (a) 1:2000 to 1:3000, (b) 1:6000 to 1:12000, and (c) 1:20000. Eleven technicians correctly located an average 10 of the 13 trees on the medium scale (b). Scale (c) was too small, and scale (a) was taken at low altitude so that it was too difficult to produce comparable sets of photographs under the conditions of the trial.

649. HARRIS, J.W.E., DAWSON, A.F., BROWN, R.G. Evaluation of mountain pine beetle damage using aerial photography, Flathead River, B.C. 1980.
Dep. Environment, Can. Forest. Serv., Pac. For. Res. Cen., Victoria, B.C. BC-X-228, 1982: 10 pp.
Subject Codes: 8.4
RCA: X1037

650. HARVEY, R.D. JR. Rate of increase of blue stained volume in mountain pine beetle killed lodgepole pine in northeastern Oregon, USA.
Canadian Journal of Forest Research, 1979, 9(3): 323-326
13 ref., 1 fig., 2 tab.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1172528

Rate of spread of blue stain fungi introduced by Dendroctonus ponderosae in recently killed trees (P. contorta) was so rapid that salvaging such trees before staining becomes severe is difficult.

651. HAWKSWORTH, F.G, LISTER, C.K, CAHILL, D.B. 1983. Phloem thickness in lodgepole pine: its relationship to dwarf mistletoe and mountain pine beetle (coleoptera: Scolytidae). Environmental Entomology 12(5):1447-1448.

A generally accepted hypotheses is that lodgepole pines (Pinus contorta) infected by dwarf mistletoe (Arceuthobium americanum) are less susceptible to

Dendroctonus ponderosae Hopk. than uninfected trees because they have thinner phloem. A study on 1051 trees in Colorado indicated that there was little relationship between dwarf mistletoe intensity and phloem thickness. It was concluded that there was little difference between dwarf mistletoe and scolytid activity, at least in Colorado.

652. HEINRICHS, J. The lodgepole killer.
Jour. of Forestry, May, 1983, 81(5): 289-292
Subject Codes: 8.1
RCA: X1112

Discusses the economic effects of infestations of mountain pine beetle on lodgepole pine in the Sierras, western Oregon, and the central and northern Rockies.

653. HIRATSUKA, Y., CEREZKE, H.F., et al. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Teritories in 1981 and predictions for 1982.
Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-239, 1982: 11 pp.
Languages: en
Summary Languages: fr
Subject Codes: 6.2
RCA: X1118

Report summarizes forest insect and disease conditions in Alberta, Saskatchewan, Manitoba and the Northwest Territories in 1981 and provides predictions for 1982.

654. HODKINSON, I.D. Long range dispersal of certain species of Psyllidae in the northern Pennines.
Entomologist's Monthly Magazine, 1972, 108(1292-1294): 21-22
1 ref.
Subject Codes: N/A
CAB: 067629

Reports the discovery in 1969 of large numbers of psyllids overwintering in a Pinus contorta plantation in the Moorehouse National Nature Reserve at an altitude of 549 m. It is suggested that they may have been blown by winds from their true food plants in the lowlands, possibly a distance of 8 miles.

655. HOLDEN, A.V., BEVAN, D. (Editors). Control of pine beauty moth by fenitrothion in Scotland - 1978.
Forestry Commission, Edinburgh, UK, 1978, publ. 1979: 176 pp.
Subject Codes: N/A
CAB: 1147064

Significant outbreaks of the native pine beauty moth (Panolis flammea) on the exotic lodgepole pine first occurred in N. Scotland in 1976. Unsuccessful attempts were made to control the increasing number of outbreaks in 1977 with preparations of Bacillus thuringiensis. In 1978, the Pesticides Safety Precautions Scheme (operated by the Ministry of Agriculture, Fisheries and Food) gave approval to the Forestry Commission for the aerial spraying of fenitrothion, provided that the operation was monitored to assess the possible risks to both humans and to various wildlife species. An area of 5 000 ha was sprayed in June, 1978 by either low-volume or ULV techniques. Reports of the monitoring operation were submitted at a discussion meeting of organizations involved in Edinburgh in October, 1978.

656. HOLDEN, A.V., STOAKLEY, J.T., et al. Aerial application of insecticide against pine beauty moth.
Occasional Paper, Forestry Commission, UK, 1981, No. 11: 112 pp.
6 ref.
Subject Codes: N/A
CAB: 1395458

The collected reports of the second year (1979) of ULV spraying with fenitrothion against Panolis flammea on 3166 ha of lodgepole pine in Scotland. Spraying was

extended to new outbreak sites at Annabaglish (Bareagle forest) in SW Scotland and in Craigellachie forest, NE Scotland, where most of these studies were made. Good control was achieved with 300 g/ha a.i. and it was concluded that there were no significant effects on people or wildlife. The 12 reports cover spraying operations (3), monitoring the human environment (3) and natural environment (5), and future spraying (1).

657. HUNT, R.S. Trisetacus (Acarina: Eriophyoidea) on Pinus contorta in British Columbia: distribution, symptoms, and provenance effect.
Canadian Journal of Forest Research, 1981, 11(3): 651-653
4 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: 1.4
CAB: 1455836

Observations were made of the occurrence of T. campnodus on potted P. contorta seedlings placed in infested plantations, and on 70 provenances growing in a 5-yr-old plantation in coastal British Columbia. The mite, which causes chlorosis and twisted foliage, could infest seedlings at any time of the year. There was considerable variation among provenances in symptom rating (0-37.5%). Coastal provenances had significantly lower ratings than interior provenances; there were also interactions with latitude and stomatal number.

658. HYNUM, B.G., BERRYMAN, A.A. Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae): gallery initiation on lodgepole pine during aggregation.
Environmental Entomology, 1981, 10(6): 842-846
16 ref., 4 fig.
Subject Codes: N/A
CAB: 1499415

Gallery starts by Dendroctonus ponderosae Hopk. were observed during aggregation on lodgepole pine (Pinus contorta) in Montana. Two phases of gallery initiation were identified: acceleration and deceleration. The acceleration phase is characterized by an increasing rate of gallery initiation and was highly variable in the trees sampled. The deceleration phase is characterized by a decreasing rate of gallery initiation and was significantly and linearly correlated with cumulative gallery starts a day or more old ($r = -0.24$). Tranformation of the data to adjust for variation between trees increased the lative gallery starts a day or more old to -0.97. The resulting improvement in correlation suggests that variation in D. ponderosae attack rates between trees can be attributed primarily to host factors. A linear model of gallery initiation during aggregation is presented.

659. HYNUM, B.G., BERRYMAN, A.A., NORRIS, D.M., BAKER, J.E. Dendroctonus ponderosae (Coleoptera: Scolytidae): pre-aggregation landing and gallery initiation on lodgepole pine.
Canadian Entomologist, 1980, 112(2): 185-191
30 ref., 1 fig.
Subject Codes: N/A
CAB: 1298730

Landing rates as monitored by landing traps in a forest in Montana in 1975 and 1976 indicated that Dendroctonus ponderosae Hopk. was not attracted to lodgepole pine (Pinus contorta) before the first gallery was started. Bark terpene odours

and DBH (diameter at breast height) were not correlated with beetle landing rates, with the exception of beta-phellandrene (3-methylene-6-(1-methylethyl)cyclohexene), which accounted for a statistically significant 18% of the variation in landing rates. Beetles were unable to distinguish between hosts, dead hosts and non-hosts before landing. The elderberry pith bioassay of D.M. Norris and J.E. Baker indicated the presence of a gallery initiation stimulant in the bark. Landings appeared to occur at random over the available vertically distributed surface areas, and gallery-initiation stimulants determined when and where trees were attacked.

660. ILNYTZKY, S., SUTHERLAND, J.R. Methyl bromide fumigation of lifted lodgepole pine seedlings for European Pine shoot moth control.

Tree Planters' Notes, 1975, 26(4): 14-15, 23
4 ref.
Subject Codes: N/A
CAB: 630999

Reports fumigation experiments on 1+1 and 2+0 Pinus contorta seedlings lifted in Feb. 1974 at Surrey, British Columbia, in the zone infested with Rhyacionia buoliana. The experiments showed that R. buoliana could be completely killed, without significant reduction in seedling survival, when the seedlings were fumigated with 1 lb MeBr/250 ft3 air in closed cardboards boxes (with holes punctured in the liner bag at each end of the box); the seedlings were stored in the boxes for up to 8 weeks before and up to 16 weeks after fumigation. Results with open boxes were somewhat less satisfactory.

661. ILNYTZKY, S., SWEETEN, J.R. Fumigation of bareroot and container-grown lodgepole pine seedlings for European pine shoot moth control.
Tree Planters' Notes, 1976, 27(4): 21-22, 33
6 ref.
Subject Codes: 7.3
CAB: 928372

Fumigation with myethyl bromide in Sept-Oct. or Feb-Mar. had no significant phytotoxic effect on 2+0 naked rooted seedlings or 1+0 container stock of Pinus contorta. Larvae of Rhyacionia buioliana were equally susceptible (99% mortality) to fumigation in spring or autumn; mortality of R. buoliana was 100% in dry conditions.

662. JOHNSON, W., AVERILL, D. Forest insect and disease conditions in the Rocky Mountain region.
Timber, Forest Pest, and Cooperative Forestry Management, Rocky Mountain Region USDA Forest Service, 1982: 42 pp.
Subject Codes: 6.2
RCA: X1103

663. KAUPP, W.J. A simple method of assessing the quantities of nuclear polyhedrosis virus entering the soil from diseased populations of European pine sawfly.
Bi-monthly Research Notes, 1980, 36(6): 31
Subject Codes: N/A
CAB: 1377618

A technique is described that was developed for assessing the amounts of nuclear polyhedrosis virus entering the soil from diseased colonies of Neodiprion sertifer (Geoffr.) in stands of lodgepole pine (Pinus contorta) in Scotland. Disposable plastic pots of volume 230 ml and diameter 10 cm, with 4 equally spaced holes punched in the sides 1 cm from the rim and containing 25 ml washed fine silver sand were placed on the ground under the canopy trees just before the sawfly eggs hatched. The pots were removed after the larvae had disappeared from the trees (either to pupate or because of virus mortality), and virus polyhedra that had accumulated in the pots were extracted from the sand and their numbers estimated. Sample results are presented, and it is suggested that the technique can be used for studying virus ecology in various insect hosts.

664. KLEIN, W.H. Beetle-killed pine estimates.
Photogrammetric Engineering, 1973, 39(4): 385-388
2 ref.
Subject Codes: N/A
CAB: 149288

A study was made to determine the feasibility of assessing the numbers of Pinus contorta killed by Dendroctonus ponderosae from examination of 35-mm colour photos on a scale of 1:5000. Counts of dead trees were made by untrained interpreters on stereo photos, and compared with ground counts. Interpreters were also required to distinguish 'new faders' (beetle-attacked trees whose crown discolours in the season following attack) from all other mortality. Both types of count were made with acceptable accuracy.

665. KLEIN, W.H. Estimating bark beetle-killed lodgepole pine with high altitude panoramic photography.
Photogrammetric Engineering and Remote Sensing, 1982, 48(5): 733-737
6 ref., 2 pl., (1 col.)
Subject Codes: 8.4
CAB: 1556694

Panoramic colour IR aerial photographs were taken in July, 1978 with an Itek KA-80A optical bar camera over stands in south central Montana dominated by Pinus contorta. Conventional aerial photographs were also collected in 1978 and 1979. Estimates of the numbers of trees killed by Dendroctonus ponderosae ("faders") and their volume from the two aerial surveys, were compared. Standard errors for fader and volume estimates for the panoramic survey were acceptable: P. ponderosa mortality in 1977 was estimated at 1891510 plus or minus 194804 trees and 27001000 plus or minus 3682000 cu.ft. in volume. Problems encountered with interpretation and data analysis are discussed. Accuracy of tree counts decreased with increasing distances from the nadir. The panoramic survey was more expensive, but covered a much greater proportion of the outbreak area.

666. KLEIN, W.H., PARKER, D.L., JENSEN, C.E. Attack, emergence and stand depletion trends of the mountain pine beetle in a lodgepole pine stand during an outbreak.
Environ. Entomol., 1978, 7(5): 732-737
Subject Codes: N/A
LISC: 235315

Yearly trends of lodgepole pine (Pinus contorta var. latifolia: Pinaceae) mortality in relationship to attacking and emerged Dendroctonus ponderosae (Col. Scolytidae) populations were measured during the life span of an epidemic within a square-mile area. Epidemic levels of infestation were recorded for 7 years, with peak tree killing occurring the 4th year. More small trees were killed than large ones, but in proportion to their occurrence the large trees were killed first and at a higher rate. Both density and total numbers of attacking and emerged beetle populations exhibited marked changes during the course of the epidemic. The patterns of total attacking and emerging beetle populations were similar to the trend of annual tree mortality, but population densities expressed on a square foot basis showed different trends. Generally, the density of attacking beetles increased during the epidemic, and while emergence remained relatively stable during the build-up years, it declined rapidly during and following the peak year of tree killing. Up to and including the year of maximum tree killing, trees of all sizes produced more beetles than they absorbed, but approached or fell below a hypothetical 1:1 emergence-attack ratio during the waning years of the outbreak. A greater percentage of emerged beetles became established in host trees during the declining years.

667. KUSCH, D.S. Pine needle scale.
Environ. Can., Can. For. Serv., North. Forest Res. Cent. Edmonton, Alberta. Pest Leafl. PL 16-77. Revised 1981.
Subject Codes: N/A
RCA: X1024

668. LAVIGNE, R.J. Life history, cultural and natural control of important insect pests in Wyoming forests.
Project WYO-169-081, P.O. Box 3354, Univ. Station, Laramie, WYO, 01 Oct 81 to 30 Sep 86
Subject Codes: N/A
CRIS: 0084358

Objectives: To validate and evaluate a cultural technique for mountain pine beetle control. To survey Wyoming to ascertain status, distribution, host plants and parasite complex of the western budworm. To determine damage potential of a pholoxyerid, Pineus sp., on lodgepole pine in southern Wyoming. To study the effect of species of the genus Laphria on forest insects, to clarify the status of the genus Laphria in North America and to provide keys to all the species. Approach: By felling, limbing, bucking and longitudinally cutting bolts of beetle infested pine trees, the effect of bark sloughing and cambial drying on brood production will be determined. Utilizing collection, light traps and rearing techniques, western budworm distribution, host plants, and parasites will be ascertained. Periodic sampling and artificial manipulation of Pineus sp. will be ascertained. Behavioral observations will be made on species of Laphria encountered in Wyoming forests. Prey will be identified and densities of the

asilids and predation rates will be related to the densities of forest pests captured. Specimens of the genus Laphria will be borrowed from museums throughout the United States, they will be identified, new species will be described and keys will be prepared to all species. Progress: A program was initiated for the cultural control of the mountain pine beetle, Dendroctonus ponderosae in October of 1981, at which time 100 trees were felled, bucked and slashed. Additional treatments will be made in April, May and June of 1982. Data will be collected during the summer season. Light traps were run at various locations throughout the state to obtain data on the distribution of the western spruce budworm, Choristoneura occidentalis. A paper is in preparation.

669. LIBBEY, L.M., RYKER, L.C., YANDELL, K.L. 1985. Laboratory and field studies of volatiles released by dendroctonus ponderosae coleoptera scolytidae. Zeitschrift Fuer Angewandte Entomologie. 100(4):381-392.

Volatiles produced by mountain pine beetles (MPB), dendroctonus ponderosae, were identified by GC/MS from air passed over emergent males, fed males, and the frass of virgin females reared from lodgepole, ponderosa, white and sugar pine. Exo- and endo-brevicomin were released by males from all four hosts. Unfed males from lodgepole pine also released diacetone alcohol; unfed males from white pine released frontalin. The frass of females from all four hosts released trans-verbenol, linalool, borneol, verbenone, myrtenol, and piperitone. Other volatiles such as cis-verbenol, trans-pinocarveol, terpinen-4-ol, alpha-terpineol, octanone, and 2-P-methen-7-ol, were detected from frass of MPB reared from certain hosts but no others, results of cross feeding experiments between MPB from white and lodgepole pine indicated that differences in frass volatiles among the populations studied result from the monoterpene composition of the host pine diet rather than from physiological differences among populations. Males reared from and fed in all four hosts released frontalin and various other volatiles. In field bioassays, 3-caren-10-ol changed the sex ratio of MPB trapped to favor males, and pinocarvone reduced the response to 48% of the attractant control. Linalool, pipertone, trans-pinocarveol, acetone, and ethanol did not affect trap catches at the evaporation rates tested. Exo-brevicomin was inhibitive at the highest concentration tested and had no effect on aggregation at lower evaporation rates down to < PPM. (-)-trans-verbenol and myrcene attracted more male MPB than (+)-trans-verbenol and (+)-alpha-pinene, respectively; but females were attracted equally. A high concentration of frontalin inhibited aggregation, but a low concentration (100 NG/H) neither inhibited nor enhanced aggregation.

670. LINDGREN, B.S. Pests of lodgepole pine, Pinus contorta, with particular reference to potential impact in Sweden.
Forest Entomology Report, Swedish University of Agricultural Sciences, 1980, (3): 125 pp.
12 pp. of ref.
Language: en
Summary Languages: sv
Subject Codes: 6.2
CAB: 1496582

A comprehensive literature review is presented of the lodgepole pine (Pinus contorta) and its associated diseases (including those transmitted by insects) and pests (including arthropods). Potential problems in Sweden are discussed. It is concluded that the tree is suitable for introduction to northern Europe and possibly elsewhere.

671. LONGHURST, C., BAKER, R., MORI, K. Response of the sawfly Diprion similis to chiral sex pheromones.
Experientia, 1980, 36(8): 946-947
10 ref.
Subject Codes: N/A
CAB: 1355087

Males of Diprion similis (Htg.) in a plantation of lodgepole pine (Pinus contorta) in Wales responded to both the (+)-(2R,3R, 7R)- and (-)-(2S, 3S, 7S)- enantiomers of its sex pheromone, erythro-3,7-dimethylpentadecan-lyl propionate. A mixture of the 2 enatiomers induced a response similar to that of the individual components.

672. LUCK, R.F., DAHLSTEN, D.L. Bionomics of the Pine needle scale, Chionaspis

pinifoliae, and its natural enemies at South Lake Tahoe, California.
Annals of the Entomological Society of America, 1974, 67(3): 309-316
39 ref.
Subject Codes: N/A
CAB: 380600

Reports a study at four infested sites, between 1969 and 1971, showing that two distinct scale populations occur sympatrically, one on Pinus contorta and one on P. jeffreyi. The P. contorta population is parthenogenetic and overwinters as eggs, while the P. jeffreyi population is bisexual and overwinters as gravid females. It is not certain whether the populations are ecotypes or distinct species. Five natural enemies associated with the scale are reported: populations on P. contorta are parasitized by the chalcidoids Prospaltella bella and Physcus howardi, while the scale on P. jeffreyi is parasitized by Achrysocharis phenacapsia; these differences persist even in mixed stands.

673. LUCK, R.F., DAHLSTEN, D.L. Natural decline of a Pine needle scale (Chionaspis pinifoliae (Fitch)) outbreak at South Lake Tahoe, California, following cessation of adult mosquito control with malathion.
Ecology, 1975, 56(4): 893-904
35 ref.
Subject Codes: N/A
CAB: 525554

A fuller account of a study already noticed of a Chionaspis pinifoliae infestation on Pinus contorta and P. jeffreyi.

674. LYON, R.L. Contact toxicity of 40 insecticides tested on pandora moth larvae.
US For. Serv. Research Note PSW-235, 1971: 1-4
Subject Codes: N/A
BIO: 72085016

675. MCCAMBRIDGE, W.F., KNIGHT, F.B. Factors affecting spruce beetles during a small outbreak.
Ecology, 1972, 53(5), 830-839
16 ref.
Subject Codes: 3.4
CAB: 098544

In 1957, Dendroctonus rufipennis beetles increased to outbreak numbers in logging slash on a north-central Colorado site, entered living Picea engelmannii trees, and remained epidemic for two years. Reduced fecundity of the beetles was the first indication of the decline of the outbreak, which was caused by nematodes and unknown agents. Significant causes of summer mortality were pitch, intro and interspecific competition for food, predation by woodpeckers and flies, and parasitization by wasps. Desiccation by both food and beetle larvae, enhanced by woodpecker feeding activity, contributed significantly to the decline. Winter mortality was attributed mainly to woodpeckers, although temperatures down to -29 deg. C caused additional losses. The effects of the outbreak on the spruce were considerable. Scattered groups of large-diameter trees were killed, and the composition of the stand was altered in favour of Abies lasiocarpa and Pinus contorta. However, mean tree diameter was not significantly reduced.

676. MCCLELLAND, B.R., LOWE, J. Response of woodpeckers and their effect on mortality of mountain pine beetles in lodgepole pine.
Project MONZ07808, Univ. of Montana, Missoula, MON, 01 May 78 to 17 June 80
Subject Codes: 6.6, 8.8.1
CRIS: 0075188

Objectives: Determine the feeding densities of woodpeckers in areas of epidemic and endemic populations of mountain pine beetle. Determine the numbers of nesting pairs of woodpeckers in these same areas. Assess woodpecker caused mortality of beetles on the study sites. Characterize active woodpecker nest trees, relating findings to forest management practices. Determine densities of other birds feeding on beetles. Approach: Locate study plots in beetle epidemic areas and control plots in endemic areas in the North Fork drainage of the Flathead River, Montana. Census woodpecker with variable-width strip sample. Locate nest sites.

Census beetle on woodpecker feeding trees and on adjacent caged trees. Assess beetle mortality. Progress: Relationships between five woodpecker species and an epidemic population of mountain pine beetles (Dendroctonus ponderosae) were studied in lodgepole pine forests of Northwestern Montana from March 1978 through September 1979. Downy (Picoides pubescens), Hairy (P. villosus) Northern Three-toed (P. tridactylus), and Pileated (Dryocopus pileatus) Woodpeckers were observed nesting in the study area and feeding on the beetles. High total densities of feeding woodpeckers were 57.3 woodpeckers per 100 acres (40 ha) in the 1977-78 Winter and 34.4 woodpeckers per 100 acres (40 ha) in the 1978 breeding season. the highest nesting density was 14.3 pairs per 100 acres (40 ha) in the 1979 breeding season. Northern Three-toed and Hairy Woodpeckers were the most abundant species in the study area, comprising 61- 100% of the feeding woodpeckers censused per season and 76% of the nests located. Feeding woodpeckers disturbed about 10% of the bark on lodgepole attacked in 1978 by beetles. This contributed to overall beetle mortality of 96-98%, but the woodpecker feeding did not appear to exert a controlling effect on the epidemic beetle population. Severe winter and summer weather conditions probably were the most important factors in causing high beetle mortality.

677. MCGHEHEY, J.H. Territorial behavior of bark beetle males (Dendroctonus ponderosae) on lodgepole pine.
Can. Entomol., 1968, 100(11): 1153
Subject Codes: N/A
BIO: 50033400

678. MCGREGOR, M.D. Occurrence of the sugar pine tortrix Choristoneura- lambertiana in the inter mountain and northern regions, USA - ponderosa pine, lodgepole pine.
J. Econ. Entomol., 1968, 61(4): 1113-1114
Subject Codes: N/A
BIO: 50033183

679. MCGREGOR, M.D. Biological observations on the life history and habits of Choristoneura-lambertiana lepidoptera tortricidae on lodgepole pine in southeastern Idaho and western Montana.
Can. Entomol., 1970, 102(10): 1201-1208
Subject Codes: N/A
BIO: 52019193

680. MCGREGOR, M.D. (et al) Mountain pine beetle in Montana, 1977. Report, Northern Region, State and Private Forestry, USDA Forest Service, 1978, No. 78-2; 78-4; 78-6; 78-8; 10 pp.; 11 pp.; 14 pp. + 1 map; 12 pp.
Subject Codes: N/A
CAB: 1500097

Four papers on the status of Dendroctonus ponderosae in stands of lodgepole pine: McGregor, M.D.; Hamel, D.R.; Oakes, R.D.; Meyer, H.E. Evaluation of mountain pine beetle in high use areas and other infested stands on the Hebgen Lake Ranger District, Gallatin National Forest, 1977 (10 ref.). McGregor, M.D.; Hamel, D.R.; Meyer, H.E. Status of mountain pine beetle infestation, Bozeman-Gallatin Ranger District, Gallatin National Forest, 1977 (14 ref.) McGregor, M.D.; Hamel, D.R., Kohler, S. Status of mountain pine beetle infestations, Glacier National Park and Glacier View Ranger M.D. Status of mountain pine beetle infestations, Kootenai National Forest, Montana, 1977 (20 ref.).

681. MCGREGOR, M.D., BENNETT, D.D., MEYER, H.E. Evaluation of mountain pine beetle (Dendroctonus ponderosae) infestation (of lodgepole pine), Hebgen Lake Ranger District, Gallatin National Forest, Montana - 1978.
Report, Northern Region, State and Private Forestry, USDA Forest Service, 1979, No. 79-6: 8 pp.
6 ref. See abstract for CAB 1500097.
Subject Codes: N/A
CAB: 1500098

682. MCGREGOR, M.D., HAMEL, D.R., OAKES, R.D. Evaluation of mountain pine beetle infestations, Thompson River drainage, Plains District Lolo National Forest,

Montana, USA, 1976.
For. Environ. Prot., US For. Serv., North Reg., 1977, 77-5: 8 pp.
Subject Codes: N/A
BIO: 77053743

683. MCGREGOR, M.D., HAMEL, D.R., OAKES, R.D. Status of mountain pine beetle infestation, Gallatin National Forest, 1976.
For. Environ. Prot. US For. Serv. North Reg., 1977, 77-12: 8 pp.
Subject Codes: N/A
BIO: 77067651

684. MCMULLEN, L.H., BETTS, R.E. Water sprinkling inhibits emergence of mountain pine beetle.
Canadian Forestry Service Research Notes, 1981, 1(2): 10-11
5 ref.
Subject Codes: N/A
CAB: 1418532

In studies in British Columbia on the control of Dendroctonus ponderosae Hopk. breeding in logs from infested trees that had been felled, 8 bolts of lodgepole pine (Pinus contorta) were sprinkled with water from a hose continuously during a storage period from 16 July to 25 August. Only 12 beetles emerged from the treated bolts, as compared with 935 from unwatered ones.

685. MCMULLEN, L.H., BETTS, R.E. 1982. Water sprinkling of log decks to reduce emergence of mountain pine beetle in lodgepole pine. Forestry Chronicle 58(5):205-206.

Experimental decks containing lodgepole pine logs infested with dendroctonus ponderosae were constructed at a mill site in British Columbia, and soaked with water from July 8 (before beetle flight) to august 18 (when most beetles would have emerged). Survival of young beetles in logs soaked by surface hoses was estimated at 4.6% compared with 92.8% survival in unsoaked controls; survival in partially-soaked logs (using a hose within the deck) was intermediate.

686. MAHER, T., MCLEAN, J.A. Investigations on the impact of the lodgepole pine terminal weevil on lodgepole pine in the B.C. interior. E.P. 894.
B.C. Ministry of For., Res. Rev., 1980-81: 54
Subject Codes: N/A
RCA: X1172

687. MAKSIMOVIC, M., ABAZOVIC, D. Damage caused by and numerical occurrence of the European pine shoot moth Rhyacionia buoliana Schiff. in Bosnia.
Zastita Bilja, 1980, 31(3): 239-248
5 ref.
Language: sh
Summary Languages: en
Subject Codes: N/A
CAB: 1366197

A study was carried out in 1978-79 on the damage caused by Rhyacionia buoliana (Denis & Schiff.) to pine plantations in 3 localities in Bosnia, Yugoslavia. The pest caused deformation of the trunks of Scotch pine (Pinus sylvestris), Austrian pine (P. nigra) and P. contorta. The rate of damage to the terminal shoot of P. sylvestris ranged from 34.5 to 78%, while up to 4.6% damage was observed to that of P. nigra and up to 30% to that of P. contorta. Control measures for the pest include the prevention of damage by the removal of infested seedlings before planting; controlling the past in surrounding plantations before planting a new one; and thinning out damaged trees. No correlation was observed between the numerical occurrence of R. buoliana and the percentage of attacked trees. It is suggested that the occurrence of the pest should be monitored using traps containing synthetic pheromone in order to rol measures.

688. MASON, R.R., TIGNER, T.C. Forest-site relationships within an outbreak of

lodgepole needle miner in central Oregon.
USDA For. Serv. Research Paper, Pacific NW For. and Range Exp. Stn., 1972, No. PNW-146: 18 pp.
17 ref.
Subject Codes: 3.7
CAB: 226660

Reports a study in 1969-70 on the occurrence of a species of Coleotechnites (C. milleri?) on Pinus contorta, after a severe outbreak in 1965-68, in relation to forest stand and site characteristics, on six pairs of plots (one of each pair in an area of high infestation and the other in an area of low infestation) in two districts of Klamath County. The outbreak occurred primarily in basins where P. contorta grows in pure stands and is the climax species. Between the defoliated stands, uninfested stands occurred in basin drainage systems where water tables were higher and stands were denser and more vigorous. Infestations were absent also on well drained slopes where P. contorta is a seral species in the P. ponderosa climax association. Influences of ground- cover type, soil temperature and depth, and moisture stress are discussed.

689. MILLER, R.H., BERRYMAN, A.A., RYAN, C.A. 1986. Biotic elicitors of defense reactions in lodgepole pin pinus contorta var latifolia. Phytocemistry. 25(3):611-612.

Elevated levels of defensive chemicals (monoterpenes) were detected in lodgepole pine (Pinus contorta var. latifolia) phloem surrounding sites inoculated with living mountain pine beetles (dendroctonus ponderosae), a blue-staining fungus (Ceratocystis clavigera), a pectic fragment from tomato leaves (PIIF) and a fungal cell wall fragment (chitosan). Chitosan elicited the greatest production of monoterpenes at the lowest concentrations, and also elicited greater responses in large, fast-growing trees. Chitosan may prove to be a useful material for assaying the resistance of conifers to lethal bark beetle attacks. The results suggest a common recognition defense mechanism in higher plants.

690. MILLER, D.R., KOSZTARAB, M. Recent advances in the study of scale insects.
Annual Review of Entomology, 1979, 24: 1-27
163 ref., 1 pl.
Subject Codes: N/A
CAB: 1032910

A review of the ecology, control, genetics, systematics, and aspects of the biology of the Coccoidea, serious pests of nut and fruit trees, woody ornamentals and forest vegetation. The interactions of several taxa with Pinus ponderosa, P. resinosa, P. contorta and P. jeffreyi are briefly described.

691. MITCHELL, R.G., WARING, R.H., PITMAN, G.B. Thinning lodgepole pine increases tree vigor and resistance to mountain pine beetle. IN: Forest Service, 29(1),March, 1983.
Subject Codes: 7.7
RCA: X1115

Thinned and unthinned stands of lodgepole pine in eastern Oregon were evaluated in 1980 to determine their vigor and susceptibility to attack by outbreak populations of the mountain pine beetle. Findings suggest that lodgepole pine can be managed through stocking control to obtain fast-growing, large-diameter trees and to avoid attack by the mountain pine beetle.

692. MOECK, H.A. Field test of Swedish "drainpine" pheromone trap with mountain pine beetle.
Bi-monthly Research Notes, 1980, 36(1): 2-3
5 ref., 3 fig.
Subject Codes: N/A
CAB: 1244743

Tests were conducted in an infested stand in British Columbia in 1979 to see whether the Swedish 'drainpipe' trap for bark-beetles could be used to take Dendroctonus ponderosae Hopk. in stands of lodgepole pine (Pinus contorta). Seven traps were deployed at intervals of 7-10 m and the baits comprised Pondelure (a 9:1 combination of trans-verbenol) ((1 alpha, 2 alpha, 5 alpha)-4,6,6-trimethylbicyclo (3.1.1)hept-3-en-2-ol) and alpha-pinene

(2,6,6-trimethyl-bicyclo(3.1.1hept-2ene)). Since Pondelure is not a good attractant in lodgepole pine stands, other attractants (ethanol, acetone or female-infested pine bolts) were used in conjunction with it in some traps. To test whether beetles were arriving at the traps but not entering them, a sticky screen cylinder was attached near the top of each trap. Although the number of beetles caught in the traps was small, the test indicated that the traps were suitable for D. ponderosae. However, the number of beetles that attacked surrounding pines far exceeded the numbers trapped. It is concluded that the pheromone available bait at present is not very effective. It is suggested from laboratory tests that a rougher surface to the pipe could increase catches by facilitating walking by the beetles on the surface. In order to reduce the catch of predators, including Enoclerus and spiders, the diameter of the holes in the trap can be reduced from 5 to 3 mm.

693. MOODY, B.H., CEREZKE, H.F. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1982 and predictions for 1983.
Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta, 1983, Inf. Rep. NOR-X-248: 19 pp.
2 ref.
Languages: en
Summary Languages: fr
Subject Codes: 6.2
RCA: X1117

Forest pest conditions in Manitoba, Saskatchewan, Alberta and the Northwest Territories during 1982 are summarized, and predictions are made for 1983. Eleven pests are discussed in detail, and additional noteworthy insect, disease and other damage agents are covered in a table.

694. MOODY, B.H., CEREZKE, H.F. 1984. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1983 and predictions for 1984. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-261.

695. MOODY, B.H., CEREZKE, H.F. 1985. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1984 and predictions for 1985. Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-269.

696. MOODY, B.H., CEREZKE, H.F. 1986. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1985 and predictions for 1986. Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-276.

697. MORRISON, B.R.S., WELLS, D.E. The fate of fenitrothion in a stream environment and its effect on the fauna following aerial spraying of a Scottish, UK forest.
Sci. Total Environ, 1981, 19(3): 233-252
Subject Codes: N/A
BIO: 73028799

To control an infestation of pine beauty moth (Panolis flammea) fenitrothion (insecticide) was applied at a rate of 300 g/ha to a forest plantation consisting primarily of lodgepole pine (Pinus contorta) and sitka spruce (Picea sitchensis) using the ultra-low volume spraying technique. The concentration of fenitrothion in the forest stream rose to a maximum of 18 .mu.g/l within the treated area 1 h after spraying but fell to 0.5 .mu.g/l after 24 h. There was no evidence that the resident fish population was disturbed by caged fish. The concentration-time profile in the fish followed closely the profile in the water and in each of the 4 fish tissues studied fell to 0.02 mg/kg after 24 h. Invertebrate drift increased 12-16 h after spraying but decreased to .approx. pretreatment levels within 48 h. Caged insects remained alive during the 5-day post- spray observation period, suggesting that drifting insects were displaced rather than killed. Concentration of fenitrothion in willow moss (Fontinalis antipyretica) fell from 0.139 mg/kg to 0.003 mg/kg (wet wt) after 48 h. Fenitrothion was not detected in sediment but this was possibly due to the low surface area/weight ratio of the particles.

698. NIJHOLT, W.W., MCMULLEN, L.H. Pine oil prevents mountain pine beetle

(Dendroctonus-ponderosae) attack on living lodgepole pine trees (Pinus-contorta). Can. Forest Service, Bi-monthly Research Notes, 1980, 36(1): 1-2
Subject Codes: N/A
BIO: 19012849

699. NIJHOLT, W.W., MCMULLEN, L.H., SAFRANYIK, L. Pine oil protects living trees from attack by three bark beetle species, Dendroctonus spp. (Coleoptera: Scolytidae). Canadian Entomologist, 1981, 113(4): 337-340
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1452698

Spraying with pine oil, a by-product of sulfate wood pulping, protected pheromone-baited living Douglas-firs, (Pseudotsuga menziesii), lodgepole pines (Pinus contorta) and spruces (Picea glauca) in British Columbia from attack by Dendroctonus pseudotsugae Hopk., D. ponderosa Hopk. and D. rufipennis (Kby.), respectively. Pine oil also protected surrounding trees and reduced the incidence of attack on trees within a radius of at least 10 m. Alpha-Terpineol ((S) - alpha, alpha, 4-trimethyl-3-cyclohexene- 1-methanol), one of the constituents of the pine oil mixture, was less effective.

700. PARKER, D.L. Trend of a mountain pine beetle outbreak.
Journal of Forestry, 1973, 71(11): 698-700
11 ref.
Subject Codes: N/A
CAB: 276035

During a 7-year infestation by Dendroctonus ponderosae in 640-acres of Pinus contorta (211 trees/acre of d.b.h. more than or equal to 5") in Yellowstone National Park, 56 trees/acre were killed by the beetle and the maximum mortality was 27 trees/acre in the fourth year. Heaviest mortality (71%) occurred in trees of d.b.h. more than or equal to 12 in.

701. PARTRIDGE, A.D., BERTAGNOLE, C.L. Interactions between bark beetles and pathogens and their influence on forest productivity.
Project IDA00811, Univ. of Idaho, Moscow, IDA, 01 Oct 81 to 31 Dec 81
Subject Codes: 8.4
CRIS: 0085700

Objectives: Determine what site and stand factors are associated with bark beetle and disease-caused mortality. Develop and test survey methods and treatment tactics. Approach: Additional total tree and site characteristics on disease sites and normal stands will be used with 10 years of existing computerized data to analyze for the effects of site disturbances, past treatment, stand dynamics, soil and other definable characteristics on the presence of disease-insect

interactions, the intensity of subsequent mortality and on changes during time. Our data will couple with the stand prognosis model now available for our area. Pathways and interactions will be defined by analyses of previous and current field observations and measurements coupled with inoculations and infestations of healthy germlings, seedlings, and trees. We will purposely combine known pathogena and associated insects during these tests. Progress: An inventory check sheet was developed for forest and forest-tree problems. The information derived from this check sheet can be computer stored directly and used for either direct diagnosis of disease or insect injury or for confirmation of diagnoses made by field personnel. The process of using the check sheet would couple well with existing stand inventories. It is intended to field test this system to confirm its reliability if funds become available.

702. PETERMAN, R.M. An evaluation of the fungal inoculation method of determining the resistance of lodgepole pine to mountain pine beetle Coleoptera scolytidae attacks.
Can. Entomol., 1977, 109(3): 443-448
Subject Codes: N/A
BIO: 64031876

Field tests were made of the fungal inoculation method of Reid et al; which

assesses the potential of individual lodgepole pine trees (Pinus contorta Dougl. var. latifolia Engelm.) to resist attacks by mountain pine beetle (Dendroctonus ponderosae Hopk.). Trees (484) were inoculated with one of the beetle's mutualistic blue-staining fungi (Europhium clavigerum Robinson and Davidson), tree response was determined, and the potential of each tree to resist D. ponderosae was predicted. Two months later, after mountain pine beetles had attacked some of these same trees, most of the predictions based on the fungal assay system were incorrect. Most of the trees which were attacked and which had been rated potentially resistant did not prevent successful bark beetle reproduction. These results, contrary to those of Shrimpton and Reid, suggest that some improvement is needed in the fungal assay method of assaying resistance of lodgepole pine to mountain pine beetle. Measures of tree resistance based on success of mountain pine beetle reproduction showed no difference in the proportion of non- resistant trees between epidemic and endemic areas.

703. POWELL, J.M. The arthropod fauna collected from the Commandra blister rust Cronartium-comandrae on lodgepole pine in Alberta, Canada.
Can. Entomol., 1971, 103(6): 908-918
Subject Codes: N/A
BIO: 52115798

704. RAFFA, K.F., BERRYMAN, A.A. Physiological differences between lodgepole pines resistant and susceptible to the mountain pine beetle and associated microorganisms.
Environ. Entomol., 1982, 11(2): 486-492
Subject Codes: 2.0
LISC: 665260

Lodgepole pines, Pinus contorta Douglas var. latifolia Engelmann, were assayed for traits associated with resistance to the mountain pine beetle, Dendroctonus ponderosae Hopkins (Coleoptera: Scolytidae). There was no relationship between resistance and the daily rate of resin flow, rate of resin crystallization, monoterpene content, monoterpene composition, or current growth rate. The major difference between trees which survived or died during exposure to naturally occurring high beetle populations was the extent of their active response to fungal invasion. Resistant trees responded to artificial inoculation with fungi vectored by D. ponderosae by forming greater quantities of resin than did susceptible trees. This wound response is general in nature, quantitatively variable, metabolically active, rapid and localized. It appears to form the major line of defense to D. ponderosae and its associated fungi, and to be related to the general vigor of the tree. The wound response was greatest in those trees which had a periodic growth ratio greater than unity.

705. RAFFA, K.F., BERRYMAN, A.A. Gustatory cues in the orientation of Dendroctonus ponderosae (Coleoptera: Scolytidae) to host trees.
Can. Entomol., 1982, 114(2): 97-104
Language: en
Summary Languages: fr
Subject Codes: N/A
LISC: 653558

Female mountain pine beetles, Dendroctonus ponderosae Hopkins, were exposed to papers soaked in outer bark extracts of lodgepole pine, Pinus contorta Douglas var. latifolia Engelmann. Both benzene and methanol-water extracts elicited greater feeding activity than did controls. Non-polar host components exhibited greater incitant (initiation of feeding) properties, while polar compounds were more powerful stimulants (continuation of feeding). No differences were detected in feeding on extracts from resistant or susceptible trees. Repellency appears to be associated with beetle responses to active host metabolism.

706. RASKE, A.G. Distribution of Monochamus larval entrance holes on lodgepole pine logs.
Bi-monthly Research Notes, 1975, 31(5): 33
3 ref.
Subject Codes: N/A
CAB: 564877

Describes the distribution of larval entrance holes of Monochamus scutellatus on

the surface of Pinus contorta logs in three different situations: small-diameter stacked logs (1); large-diameter stacked logs (2); and logs scattered on the forest floor (3). In (1), fewer entrance holes were found at the top and bottom of the log than on the sides, probably because the bottom of the log is inaccessible for oviposition and the top unsuitable and too dry for larval feeding. In (2), more entrance holes occurred at the top and bottom of the log than at the sides, probably because the tops and bottoms of these logs were often not in contact with adjacent logs, thus allowing greater use of these areas for oviposition and larval feeding. The density of entrance holes on (3) was about twice that of the adjacent stacked logs; the reason for this is unknown. The distribution of entrance holes is about the same as the distribution of the larvae because most larvae enter the log within or adjacent to their feeding areas. The determination of this distribution should make sampling estimates for larvae and their damage more efficient.

707. RASMUSSEN, L.A. Attraction of mountain pine beetles to small-diameter lodgepole pines baited with trans-verbenol and alpha-pinene.
Journal of Economic Entomology, 1972, 65(5): 1396-1399
6 ref.
Subject Codes: N/A
CAB: 091391

In trials in Idaho, Pinus contorta trees of more than or equal to 8.9" d.b.h. were baited with trans-verbenol and alpha-pinene to attract Dendroctonus ponderosae beetles. Baited trees were usually attacked before unbaited controls, although in most cases the attacks were not successful. It is suggested that the chemicals might be used to attract beetles into areas with baited trees, but not to baited trees exclusively.

708. RASMUSSEN, L.A. Flight and attack behaviour of mountain pine beetles in lodgepole pine in northern Utah and southern Idaho.
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1974, No. INT-180: 7 pp.
18 ref.
Subject Codes: N/A
CAB: 363572

Reports observations on the behaviour of Dendroctonus ponderosae adults during flight and attack in stands on Pinus contorta var. latifolia. In general, temperatures within the range 19 deg -32 deg C favoured beetle activity (e.g. emergence, daily duration of flight, etc.). The north aspect of trees received the most attacks (36%) and the south aspect the least (18%), the mean height of attack was 4.69 ft., the sex ratio of attacking adults was 1:2.3 in favour of females, all females mated within 10 days of a mass attack, and mated females constructed galleries faster than unmated females.

709. RASMUSSEN, L.A. Keys to common parasites and predators of the mountain pine beetle.
USDA For. Serv. Gen. Tech. Rep., Intermountain For. and Range Exp. Stn., 1976, No. INT-29: 4 pp.
Subject Codes: N/A
CAB: 856481

An aid for the field identification of the 8 commonest parasites and predators of Dendroctonus ponderosae in the Pinus contorta forests of the Intermountain area.

710. RASMUSSEN, L.A. Emergence and attack behaviour of the mountain pine beetle in lodgepole pine.
Res. Note, Intermountain For. and Range Exp. Stn., 1980, INT-297: 7 pp.
Subject Codes: N/A
LISC: 562427

Factors influencing the behaviour of mountain pine beetles (Dendroctonus ponderosae: Col., Scolytidae) infesting lodgepole pine were studied. More and larger beetles emerged from trees having thickest phloem, with the largest beetles usually emerging first. Beetles emerging in 1974 constructed more galleries and laid more eggs than did those in 1975 and larger size of the females. Trees that were successfully mass attacked had lower inner bark temperatures than trees unsuccessfully attacked. The sex ratio of emerging beetles was 1.52:1, females to males; for attacking beetles it was about the same, 1.50:1, but for the boring

beetles it was 2.34:1.

711. REID, R.W., GATES, H.S. Relations between some physiological functions in lodgepole pine and resistance to the mountain pine beetle.
Info. Report, Northern Forest Research Centre, Canada, 1972, No. NOR-X-15: 35 pp.
5 ref.
Subject Codes: N/A
CAB: 122303

Radial xylem growth and seasonal bole expansion and contraction were measured in 1967-69 on 19 trees of Pinus contorta var. latifolia in a stand in British Columbia that had been inoculated with Europhium sp., the response to which was used as an indicator of resistance of the trees to attack by Dendroctonus ponderosae. Ten trees were rated as resistant and nine as non-resistant. The non-resistant trees showed more bole contraction during dry periods than did resistant trees. Results for some other sample plots in which moisture tension and starch accumulation were also measured were inconclusive.

712. RICHMOND, C. 1985. Effectiveness of two pine oils for protecting lodgepole pine Pinus contorta var. latifolia from attack by mountain pine beetle dendroctonus ponderosae coleoptera scolytidae. Canadian Entomologist. 117(11):1445-1446.

713. ROBERTS, F.C., LUCK, R.F., DAHLSTEN, D.L. Natural decline of a pine needle scale population at South Lake Tahoe.
California Agriculture, 1973, 27(10): 10-12
Subject Codes: N/A
CAB: 305132

In a study of a Chionaspis pinifoliae infestation on Pinus contorta and P. jeffreyi in South Lake Tahoe, California, the outbreak was attributed to a decline in natural enemies caused by the regular application of malathion for mosquito control. In laboratory tests, mortality of parasites was increased by the malathion treatment. When malathion applications were discontinued, predators reduced the population of the scale insect to a density at which the parasite complex could resume regulation of the scale.

714. ROE, A.L., AMMAN, G.D. The mountain pine beetle in lodgepole pine forests.
US Forest Serv. Research Paper, INT-71, 1970: 1-23
Subject Codes: N/A
BIO: 51121739

715. RYKER, L.C. Management of bark beetle population using pheromones.
Project ORE-252, Oregon State Univ., Corvallis, ORE, 30 Oct 63 to 31 Dec 84
Subject Codes: N/A
CRIS: 0005126

Objectives: Identify and bioassay the last three substances isolated from the Douglas-fir beetle and identify inhibitory and attractive pheromones of the mountain pine beetle in its principal host trees - i.e. western white, ponderosa, lodgepole and sugar pines: test the inhibitory pheromones in various promising combinations in stands of the respective four host trees, study bark beetle acoustic response to various inhibitory pheromones in order to clarify their role in the behavioral sequences that stop attraction to an attacked tree. Approach: Identification by couples gas chromotography/mass spectrometer will be followed by laboratory bioassay utilizing specialized equipment for monitoring auditory as well as olfactory response. Then field tests will be made of the identified components in test for compounds and combinations that inhibit the effect of the attractants. When possible the most effective methods of deployment of the inhibitor compounds will be sought with the objective to prevent aggregation of bark beetles to susceptible stands or windthrow. The role of acoustic signals of the bark beetles in the process of aggregation and masking will be investigated and their application in the prevention of beetle aggregation sought. Progress: (81/01 81/12) In an attempt to clarify the basic behavior and differences in pheromone-mediated aggregation behavior of populations of Dendroctonus ponderosae, terpenoid compounds identified by GC/MS of volatiles released by living female beetles infesting either ponderosa, lodgepole, sugar or western white pine were

compared. Each population relased a distinct complex of compounds. Preliminary results of cross-feeding experiments with lodgepole and white pine-derived beetles indicate that the compounds released are host-determined. Field tests of four of these compounds were inconclusive: however, three compounds had antiaggregative effects in pheromone-baited traps. Exo-Brevicomin and frontalin both reduced trap catches in stands of logepole and ponderosa pine.

716. RYKER, L.C., RUDINSKY, J.A. Field bioassay of exo-and endo-brevicomin with Dendroctonus ponderosae in lodgepole pine.
Journal of Chemical Ecology, 1982, 8(4): 701-707
22 ref.
Subject Codes: N/A
CAB: 1523982

Both exo- and endo-isomers of brevicomin (7-ethyl, 5-methyl-6, 8-dioxabicyclo (3.2.1) octane) reduced the response of flying adults of Dendroctonus ponderosae Hopk. to an attractant composed of the trans-isomer of verbenol (4.6.6-trimethylbicyclo (3.1.1) hept-3-en-2-ol) and terpenes or of trans- and cis-verbenol and terpenes in a stand of Pinus contorta var. murrayana in Oregon, USA. These data suggest that racemic exo- and endo-brevicomin may interrupt aggregation in populations of the beetle colonising P. c. murrayana; the functions of the natural chircal compounds are unknown.

717. SAFRANYIK, L. Some characteristics of the spatial arrangement of attacks by the mountain pine beetle, Dendroctonus ponderosae (Coleoptera: Scolytidae), on lodgepole pine.
Canadian Entomologist, 1971, 103(11): 1607-1625
15 ref.
Subject Codes: N/A
CAB: 052128

Presents evidence to support the hypothesis that the spatial arrangement of attacks by D. ponderosae on Pinus contorta var. latifolia is largely determined by the pattern of bark niches suitable for initiation of attack. The density of suitable attack sites and bark thickness are important in determining the potential area available for attack, and also the upper limit of attacks. At fixed levels on the clear bole of naturally infested trees the pattern tends to be regular, but the regularity of the attack pattern is disturbed by the presence of an attack-density gradient round the stem circumference. The vertical attack-density gradient over the host is well described in terms of a relation between attack density and bark thickness. This relation is asymptotic and rests on the assumption that the density of bark niches suitable for initiation of attack approaches an upper limit with increasing bark thickness. There is an appendix by C. Vithayasai on the statistical analysis of the "hole-pairs" experiment.

718. SAFRANYIK, L. Size- and sex-related emergence, and survival in cold storage, of mountain pine beetle adults.
Canadian Entomologist, 1976, 108(2): 209-212
11 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 631020

Larvae of Dendroctonus ponderosae were reared to the adult stage at 21 plus or minus 3 deg C in naturally infested bolts of Pinus contorta var. latifolia in British Columbia. The mean pronatal width of the emerging beetles of both sexes decreased, and the ratio of males to females increased, during the period of emergence. Larger individuals survived longer when the beetles were stored at 1 plus or minus 2 deg ; the ratio of males to females of the surviving beetles decreased during storage. The results suggest that stress-induced mortality in the larvae and/or adults may cause increases in the adult size, and decreases in the ratio of males to females, in natural populations of D. ponderosae.

719. SAFRANYIK, L., JAHREN, R. Host characteristics, brood density and size of mountain pine beetles emerging from lodgepole pine.
Can. Dep. Fish, Forest, Bi-monthly Research Notes, 26(4), 1970: 35-36

Subject Codes: N/A
BIO: 71010083

720. SAFRANYIK, L., LINTON, D.A. 1985. The relationship between density of emerged dendroctonus ponderosae (coleoptera: Scolytidae) and density of exit holes in lodgepole pine. Canadian Entomologist. 117(3):267-275.

The relationship between the density of insect exit holes (X1) and the density (Y) of emerged adults of Dendroctonus ponderosae was investigated in naturally infested lodgepole pines (Pinus contorta) in south-central British Columbia. The density of exit and ventilation holes (HO) that were present in the bark before beetle emergence averaged 10% of all holes present after the emergence period. There was a weak but significant inverse relationship between HO and both phloem thickness and the density of emerged beetles. Painting the bark with light-colored latex paint did not affect survival or the temporal pattern of beetle emergence but ensured identification and greatly enhanced counting of fresh exit holes. Of the several regression models investigated, the relation between Y and both X1 and X2 (= X1 - HO) was best fitted by a log-log linear model. A method is suggested for setting limits on the size of exit holed cut by D. ponderosae in order to exclude from X2 much of the variation caused by exit holes of associated insects. A simple mathematical model was developed of the relationship between mean density of exit holes and the density of emerged adults of D. ponderosae.

721. SAFRANYIK, L., RASKE, A.G. Sequential sampling plan for larvae of Monochamus in lodgepole pine logs.
J. Econ. Entomol., 1970, 63(6): 1903-1906
Subject Codes: N/A
BIO: 52042616

722. SAFRANYIK, L., SHRIMPTON, D.M., WHITNEY, H.S. An interpretation of the interaction between lodgepole pine, the mountain pine beetle and its associated blue stain fungi in western Canada. IN: Management of Lodgepole Pine Ecosystems. USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 406-428
25 ref.
Subject Codes: N/A
CAB: 770080

Describes the relation between Pinus contorta and Dendroctonus ponderosae with its associated bluestain fungi (Ceratocystis montia and Europhium clavigerum). Climatic variables that affect this relation are identified and a map of hazard ratings for western Canada is presented, based on these variables. Methods are outlined for reducing losses from attacks by D. ponderosae.

723. SAFRANYIK, L., SHRIMPTON, D.M., WHITNEY, H.S. Management of lodgepole pine to reduce losses from the mountain pine beetle.
Can. For. Svc., Forestry Tech. Rept. No. 1, Oct. 74, Reprinted 1982: 24 pp. 40 ref.
Subject Codes: N/A
RCA: X1125

This two-part report is directed to forest managers, as well as to others concerned with the practice of forestry and the forest environment. The first part, written in nontechnical language, covers all aspects of problems associated with the mountain pine beetle, including procedures and guidelines for coping with this insect, along with a selected reading list. Described in the second part are the biological interactions that occur when bark beetles attack trees. This section with its bibliography forms the basis for part one and can be referred to if satisfactory decisions cannot be made with the first part alone.

724. SAFRANYIK, L., VITHAYASAI, C. Some characteristics of the spatial arrangement of attacks by the mountain pine beetle Dendroctonus-ponderosae Coleoptera scolytidae on lodgepole pine.
Can. Entomol., 1971, 103(11): 1607-1625
Subject Codes: N/A
BIO: 53042442

725. SAFRANYIK, L., WHITNEY, H.S. Using explosives to destroy mountain pine beetle broods in lodgepole pine trees.
Journal of the Entomological Society of British Columbia, 1980, (77): 3-14
12 ref., 3 fig.
Subject Codes: N/A
CAB: 1392136

The effectiveness of explosives for destroying Dendroctonus ponderosae Hopk. in individual lodgepole pine trees (Pinus contorta) was investigated in British Columbia. Two types of detonating cord and various placements were tested on infested bolts and trees, and a plastic explosive was tested on bolts. Explosives killed broods directly, and indirectly by habitat disruption. Direct effects extended about 9 cm from the explosion, and mortality was inversely related to distance. Indirect effects from extensive loosening and shedding of the bark caused far greater mortality than direct effects. On trees, summer and autumn treatment was much more effective than spring treatment, regardless of cord placement. Autumn treatment using 10 g/m detonating cord wrapped helically on to the boles at spacings of 10, 20 and 30 cm caused 100, 98 and 70% mortality of broods, respectively. Generally, vertical placement of the cord into grooves cut through the bark caused more bark disruption, and therefore more brood destruction, than did helically wrapped cord placed on the surface.

726. SARTWELL, C., DATERMAN, G.E., KOERBER, T.W. et al. Distribution and hosts of Eucosma sonoman as determined by trapping with synthetic sex attractants.
Annals of the Entomological Society of America, 1980, 73(3): 254-256
11 ref., 1 fig.
Subject Codes: N/A
CAB: 1340277

Adult males of Eucosma sonomana Kearfott were capture by traps baited with (2)-9-dodecenyl acetate and a 50:50 mixture of the Z-9 with the E-9 isomer in most parts of the range of Pinus ponderosa and P. contorta in the western USA. This borer was also trapped in pure stands of P. jeffreyi, P. attenuata and P. radiata. The relative responses of males to a wide variety of isomer blends were similar to Colorado, Montana and Washington State, a 70:30 mixture being the most attractive in each test.

727. SCHENK, J.A., MAHONEY, R.L., MOORE, J.A., ADAMS, D.L. A model for hazard rating lodgepole pine stands for mortality by mountain pine beetle Dendroctonus-ponderosae.
For. Ecol. Manage., 1980, 3(1): 57-68
Subject Codes: 7.0, 8.0
BIO: 71023462

A stand hazard rating (SHR) was developed to rate lodgepole pine stands for tree mortality caused by the mountain pine beetle. The stand hazard rating is a function of Crown Competition Factor (CCF) and percent lodgepole pine (PLPP) basal area, SHR = CCF times PLPP. This model assists forest managers in assigning priorities for the applications of silvicultural treatments to prevent or reduce the level of lodgepole pine mortality induced by mountain pine beetle.

728. SCRIVEN, G.T., LUCK, R.F. Susceptibility of pines to attack by the Nantucket pine tip moth in southern California.
J. Econ. Entomol., 1980, 73(2): 318-320
Subject Codes: N/A
LISC: 515359

Forty species of pine, were tested for susceptibility to attack by Rhyacionia frustrana (Lep., Tortricidae) at a planting in San Diego Co., California. Those pine species known to be susceptible to moth attacks in the southeastern USA and planted in San Diego Co. showed the same pattern of susceptibility with 2 exceptions: P. caribea reported as a host of the moth remained unattacked and P. glabra was attacked in San Diego Co. but is not reported as a host. A higher proportion of the hard pine species (Pinus) was attacked than were the soft pine species (Strobus). Although 4 native California species were susceptible, (Monterey pine, P. radiata, bishop pine, P. muricata, lodgepole pine, P. contorta, and digger pine, P. sabiniana) the moth is not thought to pose a serious threat to these species in their native stands.

729. SHRIMPTON, D.M. Age and size-related response of lodgepole pine to inoculation with Europhium clavigerum.
Canadian Journal of Botany, 1973, 51(6): 1155-60
13 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 257632

In 1970, 280 Pinus contorta trees 8-140 years old, in the E. Kootenay region of British Columbia, were inoculated with the bluestain fungus E. clavigerum. The resinous response of the tree to this inoculation was used as a measure of potential resistance to barkbeetle attack. Trees 31-50 years old had the greatest frequency of potentially resistant individuals. In the following year, 250 trees 10-120 years old were inoculated on 11th June, 5th July and 23rd July, with similar results. The youngest trees (10-30 years old) and oldest trees (91-120 years) showed a greater decrease in frequency of resistant individuals, as the summer progressed, than did trees of three intermediate age classes. Trees rated as resistant on the basis of all three inoculations had faster growth rate and thicker phloem than those rated as non-resistant.

730. SHRIMPTON, D.M. (Proc. Ed.). Proceedings of the joint Canada/USA workshop on mountain beetle related problems in western North America.
Pac. For. Res. Centre, Victoria, B.C., BC-X-230, 1982: 87 pp.
Language: en
Summary Languages: fr
Subject Codes: N/A
RCA: X1102

This two-day workshop on the economic and social problems related to the current mountain pine beetle epidemics in western Canada and the United States was jointly sponsored by the Canadian Forestry Service and the U.S. Forest Service in cooperation with the Alberta and B.C. Forest Services. Reports in the workshop covered: the causative agents; the extent of the problem, economics and research needs; what is now being done and future plans; accomplishment barriers; and case studies.

731. SHRIMPTON, D.M., REID, R.W. Change in resistance of lodgepole pine to mountain pine beetle between 1965 and 1972.
Canadian Journal of Forest Research, 1973, 3(3): 430-432
7 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 257631

In 1965 and 1972, 100 trees of Pinus contorta var. latifolia in each of two areas near British Columbia, were graded for resistance to Dendroctonus ponderosae by evaluating their response to inoculation with a fungus carried by the beetle. Most trees rated as non-resistant in 1965 had been killed by the beetle by 1972, whereas most trees rated as resistant in 1965 were still alive and were again rated as resistant. However, results showed that the resistance grading of some of the trees had altered during the 7-year period.

732. SHRIMPTON, D.M., THOMSON, A.J. 1980. Use of physiological maturity to identify hazard of lodgepole pine stands from mountain pine beetle. In Hazard-rating systems in forest insect pest management: symposium proceedings. Athens, Georgia. General Technical Report WO-27, USDA Forest Service, Washington, D.C. Pages 149-153.

733. SHRIMPTON, D.M., THOMSON, A.J. 1983. Growth characteristics of lodgepole pine Pinus contorta var latifolia associated with the start of mountain pine beetle Dendroctonus ponderosae outbreaks. Canadian Journal Forest Research. 13(1):137-144.

The dynamics of tree and stand growth were studied in six small but expanding

pine beetle outbreaks in British Columbia (Canada). Stands had exceeded a previously reported hazard threshold of age 80 years by 26 years, and a 2nd frequently used hazard threshold of 20.5 cm mean d.b.h. (diameter, breast height) was exceeded by 37 yr. However, stands had exceeded maturity, as defined by the intersection of current annual increment (CAI) and mean annual increment (MAI), by an average of only 17 yr. in all cases, the beginnings of the outbreaks were coincident with a period of reduced tree growth. This reduced tree growth was difficult to detect at breast height, with a consequent failure of the periodic growth ratio to indicate susceptibility. Although the stands were past the point of maturity, the dominant and codominant trees continued to add significant wood volume, which could make surveillance for incipient outbreaks and subsequent control actions cost effective.

734. SHRIMPTON, D.M, THOMSON, A.J. 1984. Growth characteristics of lodgepole pine associated with the start of mountain pine beetle outbreaks. Canadian Journal Forest Research. 13(1):137-144.

The dynamics of tree and stand growth were studied in six small but expanding dendroctonus ponderosae outbreaks in British Columbia. Stands had exceeded a standard hazard threshold of age 80 yr by 26 yr, and another standard threshold of 20.5 cm mean D.B.H. by 37 yr. However, they had exceeded maturity, as defined by the intersection of C.A.I. and M.A.I, by an average of only 17 yr. In all cases, the beginnings of the outbreaks were coincident with a period of reduced tree growth. This reduced tree growth was difficult to detect at B.H., with a consequent failure of the periodic growth ratio to indicate susceptibility. Although the stands were past the point of maturity, the dominant and codominant trees continued to add significant wood vol. which could make surveillance for incipient outbreaks and subsequent actions control cost effective.

735. SHRIMPTON, D.M, THOMSON, A.J. 1985. Relationship between phloem thickness and lodgepole pine growth characteristics. Canadian Journal Forest Research. 15(5):1004-1008.

Depth of the phloem (inner bark) layers in lodgepole pine (Pinus contorta var. latifolia) is a factor in the development of outbreaks of the mountain pine beetle (Dendroctonus ponderosae). Five lodgepole pine stands in the interior of British Columbia spanning the ages affected by this beetle (47-147 yr) were studied. Relationships were determined between thickness of the phloem layer and radial and B.A. increments over various periods of time, as well as D.B.H. The thickness of the phloem layer declined over the age spanned in this study. The best predictor of phloem thickness was the B.A. increment in the 6-10 yr before sampling. D.B.H. was a poor predictor of phloem thickness.

736. SMITH, R.H. Low concentration of lindane plus induced attraction traps mountain-pine beetle.
USDA For. Serv. Res. Note, Pacific SW For. and Range Exp. Stn., 1976, No. PSW-316: 6 pp.
8 ref.
Subject Codes: N/A
CAB: 878475

In a field experiment in 1975, lindane emulsion was applied to a group of 10 Pinus contorta trees adjacent to another group attached by Dendroctonus ponderosae the previous year. Lindane was applied at 0.3% to one central trap tree (to kill beetles) and at 1.0% to the 9 surrounding trees (to protect the trees). Cages containing 50-70 beetles and freshly cut bolts were used as a source of attraction throughout the flight period. Traps placed at the base of trees were used to estimate the total number of beetles killed. Large numbers (approx. 5000) were killed on the trap tree, 63% falling into traps within 2 ft. of the tree base. There was a marked reduction in the number of attacked trees in the general vicinity of the sprayed group, compared with the previous ten years.

737. SMITH, R.H., TROSTLE, G.C., MCCAMBRIDGE, W.F. Protective spray tests on 3 species of bark beetles in the western USA.
J. Econ. Entomol., 1977, 70(1): 119-125
Subject Codes: N/A
BIO: 63062608

In an early extensive series of tests, 2% oil solution or aqueous emulsion of lindane or chlorpyrifos, or 2% oil or water suspension of carbaryl prevented both attracted and forced attacks by Dendroctonus brevicomis LeConte, D. ponderosae Hopkins, and D. adjunctus Blandford on Pinus ponderosa Lawson and attacks by D. ponderosae on P. contorta Douglas. The period of effectiveness varied from 3 to more than 36 months depending on the formulation, insecticide and type of attack: oil solution greater than emulsion; lindane greater than chlorpyrifos greater than carbaryl; forced attacks greater than attracted attacks. No marked differences could be found between beetle species in a given location. In a later series of attracted attack tests on ponderosa pine, however, 2% water emulsion of chlorpyrifos was not effective against D. ponderosae.

738. SPEIGHT, M.R. Tree pests,. 4. European pine sawfly, Neodiprion sertifer (Geoff). 5. Beech scale (Cryptococcus fagisuga Lind) and ambrosia beetle (Xyloterus domesticum (L))
Aboricultural Journal, 1981, 5(1/2): 23-25; 143-146
Subject Codes: N/A
CAB: 1500106

Two general accounts of the ecology and life cycle of common pests in Britain: (4) N sertifier causes severe defoliation of lodgepole pine in Scotland and N. England. Successful control has been achieved using nuclear polyhedrosis viruses. (5) C. fagisuga feeds on the inner bark layers of beech trees, allowing spores of Nectria spp. to invade exposed tissues. The combination of these two factors is known as beech bark disease, and appears to be increasing in the UK. Dead and dying trees are invaded by X. domesticum, which introduces blue-staining fungi and weakens the trees with tunnels, causing "beech snap". Control of beech bark disease is mainly by removing affected trees.

739. STARK, R.W. Distribution and life history of the lodgepole needle miner (Recurvaria sp.) (Lepidoptera:Gelechiidae) in Canadian Rocky Mountain Parks.
Can. Ent., 1954, 84(1):1-12
Subject Codes: N/A
RCA: X1217

740. STARK, R.W., BOURCHIER, R.J. Needle miner and needle cast on lodgepole pine in Alberta.
Can. Dept. Agric., Forest Biol. Div., Mimeograph, 1956, Calgary, Alberta.
Subject Codes: N/A
RCA: X1218

741. STERNER, T.E., DAVIDSON, A.G. (compilers). Forest insect and disease conditions in Canada 1981.
Forest Insect and Disease Survey, Canadian Forestry Service, Ottawa, 1982: 46 pp.
Subject Codes: 6.2
RCA: X1146

The report contains estimates of the average annual depletion caused by important pests over the period 1977-81. Major forest insects and diseases and their distribution are outlined.

742. STEVENS, R.E. Association of Pityophthorus opimus with Pissodes terminalis in Colorado lodgepole pine (Coleoptera: Scolytidae & Curculionidae).
Coleopterists Bulletin, 1973, 27(3): 141-142
4 ref.
Subject Codes: N/A
CAB: 276030

Reports Pinus contorta in N. Colorado as a new host of P. Opimus, which behaves as a commensal of the primary weevil Pissodes terminalis. Only the leaders are attacked by either species: the weevil feeds on the phloem for a short while and then moves into the pith, and the barkbeetle then feeds on the remaining phloem.

743. STEVENS, R.E., KNOPF, J.A.E. Lodgepole terminal weevil in interior lodgepole forests.
Environmental Entomology, 1974, 3(6): 998-1002

15 ref.
Subject Codes: N/A
CAB: 419339

Pissodes terminalis is a widespread pest of Pinus contorta (var. latifolia) in the central Rocky Mts. and Intermountain area of the north-western USA. Studies in stands in Colorado and Idaho in 1968-72 indicated that the life history and habits of the weevil are similar to those reported elsewhere. Infestations are heaviest in stands where the trees are 5-20 ft tall, and decline as trees outgrow this height class. In one study area ca. 50% of the trees had been infested at least once, and some repeatedly. Dense stands are infested most frequently.

744. STEVENS, R.E., SARTWELL, C., KOERBER, T.W., et al. Western Rhyacionia (Lepidoptera: Tortricidae Olethreutinae) pine tip moths trapped using synthetic sex attractants.
Canadian Entomologist, 1980, 112(6): 591-603
8 ref., 7 fig.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1325483

Synthetic sex attractants were used to trap adults of Rhyacionia spp. associated with pine (Pinus spp.) throughout the western USA in 1977 and 1978. Some species were shown to have much wider distributions than previously known. Among species caught in traps baited with (8E, 10E)-8, 10-dodecadienyl acetate, R. busckana Heinr. was found widely throughout the north-west, for the first time in Montana and Wyoming, and R. fumosana Powell was captured throughout the Rocky Mountain states, with new records for Montana, Utah and Nevada. Sets of 2 previously unknown moths similar to R. zozona were collected. One was closely associated with the typical form in Oregon and California; the other was associated with pinyon (P. cembroides) in Colorado and New Mexico. In all, 9 of the 14 native species of Rhyacionia in the western USA were taken. North American Rhyacionia have been assigned to 11 species groups, on the basis of morphological and biological characters, a relation between attractants and these taxonomic groups is described. The species associated with different species of Pinus, including P. ponderosa, P. strobiformis, P. edulis, P. radiata, P. jeffreyi, P. contorta, P. flexilis, P. monticola, P. monophylla, P. aristata, P. lambertiana and P. attenuata, are described.

745. STOAKLEY, J.T. Pine beauty moth - a new pest of lodgepole pine in north Scotland.
Res. Info. Note, Forestry Commission, UK, 1976, No. 17-76-ENTON: 2 pp.
Subject Codes: N/A
CAB: 746990

Describes the appearance, life-history and distribution of the Pine beauty moth, Panolis (a common pest on Scots Pine) and reports a severe outbreak in 1976 affecting 180 ha of 9-18 year-old lodgepole pine (Pinus contorta), two-thirds of which was totally defoliated. A wide range of provenances appeared to be similarly affected; the relative susceptability of other species present is mentioned. Author's summary.

746. STOAKLEY, J.T. A severe outbreak of the pine beauty moth on lodgepole pine in Sutherland.
Scottish Forestry, 1977, 31(2): 113-125
5 ref.
Subject Codes: N/A
CAB: 915038

The first occurrence of Panolis flammea in Pinus contorta plantations in Caithness and Sutherland was reported in 1973. Severe defoliation of 120 ha in Naver Forest, Sutherland, in 1976 is described. A pupal survey was made on the affected area. There was no apparent correlation between degree of defoliation and obvious site factors, fertilization regime, tree age or provenance, an apparent gradation from (a) low to (b) high defoliation was due to the existence of two statistically separate populations. A good correlation between pupal weights and defoliation was found in (a); but not in (b). Numbers of pupae were generally very high. Numbers of diseased larvae, although strongly correlated with total pupae, were not density dependent. The financial loss incurred was appraised. Possible preventative measures are discussed.

747. STOAKLEY, J.T. The pine beauty moth - its distribution, lifecycle and importance as a pest in Scottish forests. IN: Control of pine beauty moth by fenitrothion in Scotland, 1978.
Edinburgh, UK, Forestry Commission, 1978, publ. 1979: 7-12
2 ref.
Subject Codes: N/A
CAB: 1147065

The larval habit of Panolis flammea of feeding on the internal tissues of needles during the first 2-3 instars made Bacillus thuringiensis preparations ineffective, since these act as a stomach poison. Lodgepole pine plantations on unflushed peatland types (dominated by Calluna vulgaris) were the focal points of outbreaks.

748. STOAKLEY, J.T. Pine beauty moth.
Forest Record, Forestry Commission, UK, 1979, No. 120: 11 pp.
6 ref., 6 pl. (col.)
Subject Codes: N/A
CAB: 1147043

A leaflet on Panolis flammea with special reference to recent oubreaks on lodgepole pine in Scotland.

749. STOCK, M.W., AMMAN, G.D. Genetic differentiation among mountain pine beetle populations from lodgepole pine and ponderosa pine in northeast Utah.
Annals of the Entomological Society of America, 1980, 73(4): 472-478
33 ref., 2 fig.
Subject Codes: N/A
CAB: 1355072

Isoenzyme comparisons were made among adults of Dendroctonus ponderosae Hopk. from 4 sites in northeastern Utah. Genetic differentiation was more closely associated with host-tree species (lodgepole pine (Pinus contorta var. latifolia) vs. ponderosa pine (P. ponderosa)) than with geographical distances between sites. Differences in average heterozygosity and frequencies at certain gene loci may be related to stage in the infestation cycle or environmental stress related to food quantity. Differences were small between males and females at any one site, but among sites males shows greater differences than did females. A difference in gene frequencies between early- and late-emerging beetles was found at one site.

750. STOCK, M.W., HIGBY, P.K. Genetic differentiation among mountain pine beetle populations. IN: UBC 2nd Int'l. Congress of Systematic and Evolutionary Biology, Vancouver, Canada, July 17-24, 1980. I + 441 pp.
University of British Columbia: Vancouver, B.C., Canada. Paper 0(0), 1980: 362
Subject Codes: N/A
BIO: 21057317

751. STRUBLE, G.R. Needle miner infestations in lodgepole pine east of the Sierra Crest, California, USA: Pinus-contorta-var-murrayana coleotechnites-milleri.
US For. Service Research Note, 1968, PSW-177: 4 pp.
Subject Codes: N/A
BIO: 50050201

752. STRUBLE, G.R. Biology, ecology and control of the lodgepole needle miner.
Tech. Bulletin, US Dept. of Agriculture, 1973, No. 1458: 38 pp.
25 ref.
Subject Codes: N/A
CAB: 149261

Summarizes the results of studies on Coleotechnites milleri in the Yosemite National Park, California, between 1954 and 1967. Aspects covered are: hosts (the principal host is Pinus contorta var. murrayana (P.c. var. latifolia)) and distribution; effect on host trees; life cycle and biology; methods of

sampling; and natural and insecticidal control.

753. SUTHERLAND, J.R., EERDEN, E.V. Diseases and insect pests in British Columbia forest nurseries.
Joint report - British Columbia Ministry of Forests/Canadian Forestry Service, 1982, No. 12: 55 pp.
Languages: en
Summary Languages: fr
Subject Codes: 6.2
RCA: X1124

This bulletin was prepared to assist nursery personnel in identifying and controlling diseases and insect problems in British Columbia forest nurseries. The bulletin contains four main sections, i.e., a beginning one containing information such as pest prevention, chemical control and diagnosis. Then follow sections on diseases affecting seeds and roots, shoot diseases, and insects and allied pests. Each of the latter three sections contain several chapters on specific pests.

754. TIGNER, T.C., MASON, R.R. Resistance to a needle miner in lodgepole pine varies with foliage source.
Environmental Entomology, 1973, 2(5): 494-497
2 ref.
Subject Codes: N/A
CAB: 276001

Resistance to defoliation of Pinus contorta by Coleotechnites sp. was investigated during an outbreak in central Oregon in the late 1960's. By means of caging studies in the field and by laboratory preference tests it was established that larvae invade some types of foliage more readily than others. The degree of resistance to attack was probably determined by a feeding deterrent in the foliage that varied according to site, tree and location in the canopy.

755. TKACZ, B.M., SCHMITZ, R.F. 1986. Association of an endemic mountain pine beetle Dendroctonus ponderosae population with lodgepole pine Pinus contorta var latifolia infected by armillaria root disease in Utah. USDA forest Service Research Note No. 353. 7p.

756. TUNNOCK, S. A chronic infestation of mountain pine beetles in lodgepole pine in Glacier National Park, Montana.
J. Entomol. Soc., British Columbia, 67: 1970
Subject Codes: N/A
BIO: 71039137

757. VALENTA, V.T., ZHEGAS, A.T. A new assortment of insecticides for use in protecting pine plantations.
Lithuanian Forest Research Institute, Kaunas 1976: 8 pp.
Languages: ru
Subject Codes: N/A
RCA: X1002

758. VIITASAARI, M. Notes on Acantholyda flaviceps (Retz.) (Hym., Pamphiliidae) in Eastern Fennoscandia.
Annales Entomologici Fennici, 1975, 41(1): 16-18
18 ref.
Subject Codes: N/A
CAB: 525587

Reports the trapping of several adult females of this little known sawfly in a pure stand of Pinus contorta var. latifolia in S. Finland, and describes its oviposition behaviour in the laboratory (on P. sylvestris needles); no larvae were obtained. A map is presented of distribution records in Finland and the north-western USSR, where it is found up to the northern limit of P. sylvestris.

759. WARING, R.H., PITMAN, G.B. Nitrogen stress and insect attack in lodgepole pine forests.
Project ORE-FS-064-P, Oregon State Univ., Corvallis, ORE, 01 Aug 78 to 30 June 84
Subject Codes: 3.3
CRIS: 0076160

Objectives: Evaluate how nitrogen availability affects the susceptibility of lodgepole pine to mountain pine beetle. Develop an alternative management option for the control of mountain pine beetle if our basic hypothesis correct. Approach: By fertilizing and thinning some stands of lodgepole pine, it is hoped that the stand resistance will increase. Alternatively, by adding sawdust and sugar, the carbon to nitrogen ratios should be raised sufficiently to increase susceptibility. Insects will initially be attracted to the experimental sites using pheromone. Resulting attacks and mortality should reflect treatments if hypothesis is valid. Researchers will monitor changes in leaf area, leaf carbohydrate and nitrogen reserves, sapwood water content, plant water stress and degree of attack. Growth and mortality will also be recorded. Progress: Manipulative experiments in 40 - 120 year old lodgepole pine forests in eastern Oregon demonstrated that mountain pine beetles kill physiologically stressed trees. Thinning a forest causes most trees to improve their vigor within a few years so that they are no longer susceptible to colonization, even in areas with epidemic beetle populations. Fertilizing with nitrogen speeds the response, whether thinning is done by man or by insects. A simple index to tree vigor is the ratio of wood production to foliage area. This can be estimated from cores of sapwood extracted at breast height. The index is indirectly correlated with volatile terpenoids produced in the inner bark which appear to attract or repel the beetles.

760. WATERS, W.E. (Editor): Current topics in forest entomology. Selected papers from the XVth Int'l. Congress of Entomology, Washington, D.C., August, 1976. Assessment and prediction of pest insect impacts on forest uses and values.
Gen. Tech. Rep., USDA FOR. Service, Washington, D.C., 1979, No. WO-8: 33-53
Subject Codes: 8.5, 8.8.2
CAB: 1514847

Kanamitsu, K. One aspect of damage to the forest caused by insects, 33-34 (5 ref.). Discusses the threshold density above which an insect is considered a pest. Klein, W.H. Measuring damage to lodgepole pine by the mountain pine beetle (Dendroctonus ponderosae). 35-42 (3 ref.) Colour aerial photography and ground survey methods. Michalson, E.L.; Findeis, J. Economic impact of mountain pine beetle (Dendroctonus ponderosae) on outdoor recreation. In Targhee National Forest, Idaho. 43-49 (3 ref.). Leuscher, W.A. Impact analysis, interpretation and modeling. 50-53.

761. WATSON, J.A. Rhythmic emergence patterns of the mountain pine beetle Dendroctonus-ponderosae coleoptera scolytidae.
Can. Entomol., 1970, 102(8): 1054-1056
Subject Codes: N/A
BIO: 52001492

762. WELLNER, C.A. Management problems resulting from mountain pine beetles in lodgepole pine forests.
IN: Symposium Proc. Theory and Practice of Mountain Pine Beetle Management in Lodgepole Pine Forests, December, 1978
Subject Coes: N/A
RCA: X1179

763. WIERSMA, N. Cone and seed insects in Europe. IN: Proceedings, a Symposium on Flowering and Seed Development in Trees.
Starkville, Mississippi, USA, Southern For. Exp. Stn., 1979: 291-304
44 ref., 2 pl.
Subject Codes: N/A
CAB: 1146916

Discusses insects on Picea abies, Larix spp., Pinus sylvestris and P. contorta in Scandinavia.

764. WINTER, T.G. Observations on the biology and some larval parasites of Rhyacionia duplana logaea Durrant (Lepidoptera: Tortricidae) in Scotland.
Entomologist's Gazette, 1979, 30(4): 257-265
11 ref., 4 fig.
Subject Codes: N/A
CAB: 1213419

Although Rhyacionia duplana logaea Durrant has long been known to occur in the UK, the larva was not found until 1969, when it was found infesting recently planted Pinus contorta in Scotland. The biology of the tortricid is described from field observations in Scotland and laboratory studies. The flight period was in April, sometimes overlapping into May; males were observed flying for about 40 min from 17.00 h. in sunny but cool conditions. The duration of adult life in females in the laboratory averaged 16 days; males lived for a shorter period. Eggs hatched in 8-15 days in the bases of pairs of needles; larvae in later instars tunnelled in the shoot to the terminal bud, then returned to make an exit hole lower down. The length of completed mines averaged 1.7 cm. The larval period lasted 3 months in June-August. Larvae left shoots to pupate, adults hatching in spring. Parasitism of larvae at a place in Scotland in 1972 averaged 17.7%, the parasites including Apanteles sp., Elachertus isadas (Wlk.), Scambus sp., Pteromalus semotus (Wlk). and unidentified chalcidoids and ichneumonhoids. A considerable number of larvae were found dead from unknown causes when shoots were dissected, and some larvae appeared to be killed by resin flooding into their mines.

765. WINTER, T.G., SCOTT, T.M. Chemical control of the Pine shoot moth, Rhyacionia buoliana (Denis and Schiffermuller) (Lepidoptera: Tortricidae) in seed orchards in Britain.
Forestry, 1977, 50(2): 161-164
Subject Codes: N/A
LISC: 080635

In 1970 and 1971 a high population of R. buoliana, the pine shoot moth, appeared in a seed orchard of Pinus contorta in Wiltshire. The opportunity was taken to compare several alternative insecticides with DDT. Field trials in March and August showed that fenitrothion can be used as an alternative to DDT to control the pine shoot moth.

766. WONG, H.R. Some insect pests of forest tree nurseries in the Canadian prairies.
Forest Management Note. No. 15, Northern Forest Research Centre, Edmonton, Alta., 1982: 4 pp.
Subject Codes: N/A
RCA: X1028

This note presents a brief description of the damage observed, identification of the insect pest, and suggestions for chemical control, if required.

767. WONG, H.R., MELVIN, J.C.E. Insects associated with trees damaged by hydrocarbon condensate in the Strachan area, Alberta.
Info. Report, Northern For. Res. Centre, Canada, 1973, No. NOR-X-74: 19 pp.
7 ref.
Subject Codes: 6.5
CAB: 363527

Liquid hydrocarbon condensate, accidentally released from a pipeline in July 1971, caused extensive damage to ca. 15 acres of mixed forest. Insects found a year later in dead, injured and uninjured trees of Picea glauca, Pinus contorta, Populus tremuloides, P. balsamifera, Betula papyrifera and Abies balsamea belonged to 4 orders, 19 families and 33 species. Most of these were associated with trees having dead crowns. More insects were collected from the base than from the centre or top of the trees. Bark- and wood-inhabiting insects were found to have done the most damage to injured trees.

## 6.2 DISEASE

768. ALEXANDER, M.E., HAWKSWORTH, F.G. Wildland fires and dwarf mistletoes: a literature review of ecology and prescribed burning.
USDA For. Serv. Gen. Tech. Report, Rocky Mountain For. and Range Exp. Stn., 1975, No. RM-14: 12 pp.
92 ref.
Subject Codes: 3.0, 6.3
CAB: 604393

This review comprises separate studies of two subject fields, viz. (a) the relations between wildfires and the distribution of Arceuthobium spp.; and (b) the use of prescribed burning as a means of controlling dwarf mistletoes. The information on (a) and (b) is further subdivided under five species heads, dealing respectively with stands of: Pinus contorta and P. banksiana; P. ponderosa; Pseudotsuga menziesii; Picea glauca and P. mariana; and other coniferous species. Some conclusions are drawn and further research is recommended.

769. ALLEN, E., HIRATSUKA, Y. 1985. Infection of young lodgepole pine seedlings with endocronartium harknessii. Phytopathology. 75(11):1279.

770. BALLARD, R.G., WALSH, M.A., COLE, W.E. 1982. Blue-stain fungi in xylem of lodgepole pine: a light-microscope study on extent of hyphal distribution. Canadian Journal of Botany 60(11):2334-2341.

This preliminary report examines distribution of the fungi in the secondary xylem and phloem of Pinus contorta var. latifolia at the time of tree death. In midsummer mountain pine beetles emerged from the trees and flew to non-infested ones. While chewing vertical egg galleries in the inner bark they innoculated it with the blue-stain fungus complex. Initially the fungi were confined to the beetle frass in the gallery but soon grew into the sapwood and spread radially via the xylem parenchyma. Once established in the xylem hyphae moved into the tracheids of the axial and water-conducting system. Here they occluded bordered-pit pairs and occasionally the entire cell lumen. Hyphae also attacked and destroyed resin-duct epithelial cells. This could result in the release of resin into surrounding tissues. Destruction of storage and water-conducting tissues in the trunk was detrimental to renewed shoot tip expansion the following spring.

771. BARANYAY, J.A. Lodgepole pine dwarf mistletoe in Alberta.
Can. Dep. Fish, Forest, Can. Forest Serv. Publ., (1286), 1970: 1-22
Subject Codes: N/A
BIO: 52074334

772. BARANYAY, J.A. Dwarf mistletoe as a factor in the management of lodgepole pine forests in western Canada. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 359-376
21 ref.
Subject Codes: N/A
CAB: 757660

Discusses the hosts and distribution of Arceuthobium americanum, the effect of past utilization of Pinus contorta stands on the spread of dwarf mistletoe and the mangement of infected sites.

773. BARANYAY, J.A., SAFRANYIK, L. Effect of dwarf mistletoe on growth and mortality of lodgepole pine stands in Alberta.
Can. Dep. Fish, Forest, Can. For. Serv. Publ. (1285), 1970: 1-19
Subject Codes: N/A
BIO: 52103933

774. BARANYAY, J.A., SMITH, R.B. Dwarf mistletoes in British Columbia and recommendations for their control.
Info. Report, Pacific For. Res. Centre, Canada, 1972, No. BC-X-72: 18 pp. 25 ref.
Subject Codes: N/A
CAB: 083803

Describes the distribution, biology, recognition and symptoms, and control of the four species of dwarf mistletoe (Arceuthobium americanum, A. tsugense, A. laricis and A. douglasii) found in British Columbia on Pinus contorta, Tsuga heterophylla, Larix occidentalis and Pseudotsuga menziesii. It is concluded that losses caused by these species can be greatly reduced through proper silvicultural management.

775. BARANYAY, J.A., SZABO, T., HUNT, K. Effect of Atropellis canker on growth and utilization of lodgepole pine.
Info. Report, Pacific Forest Research Centre, Canada, 1973, No. BC-X-86: 22 pp. 32 ref.
Subject Codes: 8.1
CAB: 267022

Studies in Alberta on the effect of Atropellis piniphila canker on the growth and the mechanical and pulping properties of infected Pinus contorta var. latifolia showed that the disease reduced the volume of infected trees by up to 56.5% and that infected trees gradually dropped out of their original crown classes. The sp.gr. of infected wood was almost double that of healthy wood, because of the high resin content. The static mechanical properties of infected wood appeared to be unaffected, whereas the dynamic and some basic physical properties were lower than those of healthy wood. Barking of infected wood for pulping was difficult, and 30% of the chips produced had to be rejected because of high resin content. The loss of pulp yield attributable to infection was 5-6% when calculated on an oven-dry extractive-free wood basis and 11.9% when calculated on an oven-dry unextracted basis. Pulp properties of infected wood were slightly inferior to those of healthy wood except for the burst factor. Bleaching was very difficult.

776. BEARD, T.H. Distribution of stalactiform blister rust on lodgepole pine in Idaho and some observations on canker development.
M.S. Thesis, Univ. of Idaho, Moscow, 1981: 57 pp.
Subject Codes: N/A
RCA: X1203

777. BEARD, T.H., MARTIN, N.E. Sites characteristic of lodgepole pine and stalactiform blister rust.
Univ. of Idaho, Forest, Wildlife and Range Exp. Sta., Technical Report 13: 19 pp.
Subject Codes: N/A
RCA: X1204

778. BEARD, T.H., MARTIN, N.E., ADAMS, D.L. 1983. Effects of habitat type and elevation on occurrence of stalactiform blister rust in stands of lodgepole pine Pinus contorta. Plant Disease 67(6):648-651.

Stalactiform blister rust, caused by cronartium coleosporioides, occurs on hard pines throughout the northern (USA) and Canada. Locations of lodgepole pine reported in disease surveys of Idaho forests, 1968-1980, showed stalactiform blister rust occurring at elevations at 1500-2477 m. Abies lasiocarpa/xerophyllum tenax and A. lasiocarpa/vaccinium scoparium were the most common habitat types supporting lodgepole pine and stalactiform blister rust.

779. BERGDAHL, D.R., FRENCH, D.W. Relative susceptibility of 5 pine species 2 to 36 months of age to infection by Cronartium-comandrae.
Can. J. For. Res., 1976, 6(3): 319-325
Subject Codes: N/A
BIO: 63029060

Five species of pines (Pinus contorta Dougl. var. latifolia Engelm., P. divaricata (Ait.) Dumont = P. banksiana Lamb., P. nigra Arn., P. ponderosa Laws. and P. sylvestris L.) were inoculated with basidiospores of C. comandrae Pk. in the greenhouse and field. For the youngest age class (2 mo.), combined

results from greenhouse and field inoculations indicate that P. sylvestris (18.8% infected) was the least susceptible. The combined infection averages for P. divaricata, P. nigra, P. contorta var. latifolia and P. ponderosa were 52.4, 58.7, 63.8 and 68.2% infection, respectively. One year old P. ponderosa seedlings had the highest percentage infection (27.5%). Except for one 3 year old P. ponderosa seedling, the seedlings older than 1 year were not infected. Pycniospores occurred within 80 days on some of the seedlings of all pine species except P. nigra (86 days).

780. BJORKMAN, E. Progress report on Swedish research on forest tree resistance to diseases.
Bull. OEPP (Organ Eur. Mediterr. Prot. Plant), 1973, (9): 17-21
Subject Codes: N/A
BIO: 56028013

781. BOLSINGER, C.L. The extent of dwarf mistletoe in six principal softwoods in California, Oregon, and Washington, as determined from forest survey records.
Gen. Tech. Rep., USDA For. Serv., Pacific SW For. and Range Exp. Stn., 1978, PSW-31: 45-54
Subject Codes: N/A
LISC: 257048

Forest inventory records show dwarf mistletoe infection in 6 principal softwoods on 23% of commercial forest land in California, Oregon and Washington. Douglas-fir dwarf mistletoe was found over the largest area. Larch and lodgepole pine were the most seriously infected.

782. BUTIN, H., SCHULER, G., SIEPMANN, R., STEPHAN, B.R. 43rd German Plant Protection Conference, Hamburg, October 5-9, 1981. Forest section.
Mitteilungen, Biologische Bundesanstalt fur Land- und Forstwirtschaft, Berlin-Dahlem, 1981, No. 203: 177-187
1 ref.
Language: de
Summary Languages:
Subject Codes: N/A
CAB: 1472604

Extended summaries of 7 papers, of which 4 are noticed below and the others (on insects) separately in Forestry Abstracts: Butin, H. (New tree diseases in W. German forests.) 177-178. Siepmann, R. (The relation between the regeneration of conifer roots and their infection by fungi present in the soil.) p. 181. Stephan, B.R. (Testing five- needle pines for resistance against blister rust (Cronartium ribicola).) Seedlings of 17 Pinus species were tested. The progeny of resistant trees of P. lambertiana and P. monticola showed significant genetic gains. 182-183. Stephan, B.R.; Butin, H. (Occurrence of Lachnellula rehmii and Crumenulopsis sororia in connection with a canker in Pinus contorta.) 184-185.

783. BYLER, J.W., PLATT, W.D. Cone infection by Peridermium-harknessii.
Can. J. Bot., 1972, 50(6): 1429-1430
Subject Codes: 2.8
BIO: 54062775

784. CARLSON, L.W., BELCHER, J. Seed and soil treatments for control of conifer seedling damping-off: Pinus-resinosa, Pinus-banksiana, Pinus-contorta, Picea-glauca, captan fungic arasan fungic.
Can. Dept. Forest. and Rural Develop., Bi-monthly Research Notes, 1969, 25(1): 4-5
Subject Codes: N/A
BIO: 69048760

785. CRAIG, M., HAYES, A.J. Distribution of Crumenulopsis sororia (Karst) groves in relation to site and crop factors in some stands of lodgepole pine of Alberta provenance.
Forestry, 1981, 54(1): 75-88

21 ref.
Subject Codes: 2.3, 3.2
CAB: 1369219

A study was made of the canker pathogen C. sororia in 10 stands 46-50 years old of lodgepole pine (2 825 trees) at Mearns Forest, Grampian Region, Scotland. In heavily infected stands co- and sub-dominant trees were more frequently cankered than were dominant and suppressed trees; the incidence of cankering and resinosis was not related to stem girth-class. Significantly ($p = 0.001$) greater numbers of cankers occurred on N and E facing sides of stems than on S and W sides. Percentage infection was negatively correlated with effective rooting depth ($r = -0.66$) and positive with percentage soil moisture ($r = +0.91$). Results suggest that limited rooting volume and variations in the microclimatic regime around individual stems may critically affect success of infection. From authors' summary.

786. COLEMAN, M.E., ANDERSON, A.J. 1985. Plant responses to rhizopogon vinicolor elicitors. Phytopathology. 75(11):1283.

787. DAVIDSON, R.W. Sapwood staining fungi from two tree species.
Memoirs of the New York Botanical Garden, 1976, 28(1): 45-49
Subject Codes: N/A
CAB: 735304

Describes Ceratocystics grandifoliae (a new species) and Diplodia natalensis from Beech (Fagus sp.) planks in Iowa and C. hyalothecium (a new species) from dead bark of Pinus contorta in Wyoming.

788. DINGLEY, J.M., GILMOUR, J.W. Colleotrichum-acutatum-f-sp-pinea: new special form associated with terminal crook disease of Pinus-spp.
New Zealand J. For. Sci., 1972, 2(2): 192-201
Subject Codes: N/A
BIO: 55035680

789. DIXON, B. 1986. UK plans to release a recombinant virus. Bio-Technology. 4(5):391.

790. DOBIE, J., BRITNEFF, A.A. Lumber grades and volumes from lodgepole pine infected with dwarf mistletoe.
Wood and Fiber, 1975, 7(2): 104-109
8 ref.
Subject Codes: 5.0
CAB: 710606

Pinus contorta with severe crown infections were sampled near Prince George, B.C., and compared with an uninfected control sample. There were no differences of practical importance between the two samples in lumber grade yields or recovery factors, but there was good evidence that volume growth is retarded by infection. Control by early removal of infected stands is therefore recommended, where this is possible.

791. DOOLING, O.J. A new distribution record for dwarf mistletoe in Montana.
Plant Dis. Rep., 1973, 57(4): 298
Subject Codes: N/A
BIO: 56068671

792. DOOLING, O.J. Evaluation of proposed dwarf mistletoe control projects for fiscal years 1976-1986, Upper Willow Creek, Phillipsburg Planning Unit, Missoula District Bureau of Land Management.
U.S. For. Serv. Div. State Priv. For. North Reg. Rep., 1975, 75(16): 1-4
Subject Codes: N/A
BIO: 75094743

793. DOOLING, O.J. Evaluation of proposed dwarf mistletoe management projects in

Montana.
Report, Northern Region, State and Private Forestry, USDA Forest Service, 1978, No. 78-13; 78-15; 78-16; 78-17; 7; 11; 8.
Subject Codes: 8.5
CAB: 1442732

Four reports describing proposed control methods for Arceuthobium spp. on 3 conifers, and including cost benefit analyses: Evaluation of proposed dwarf mistletoe management projects on the White Sulphur Springs Ranger District, Lewis & Clark National Forest - lodgepole pine and A. americanum; Evaluation of proposed dwarf mistletoe management projects on the Swan Lake Ranger District, Flathead National A. laricis; Evaluation of proposed dwarf mistletoe management projects on the Deerlodge National Forest - lodgepole pine and A. americanum; Evaluation of proposed dwarf mistletoe management projects on the Sula Ranger District, Bitterroot National Forest - Douglas-fir and A. douglasii.

794. DOOLING, O.J., BROWN, D.H. Guidelines for dwarf mistletoe (Arceuthobium americanum) control in lodgepole pine in the northern and central Rocky Mountains.
Report, Northern Area, State and Private Forestr, USDA Forest Service, 1976, No. 76-14: 10 pp.
5 ref.
Subject Codes: N/A
CAB: 1442731

795. ESLYN, W.E. Golden stain of lodgepole pine (Pinus contorta Dougl. ex Loud.) heartwood.
Phytopathology, 1979, 69(5): 539-540
Subject Codes: N/A
CAB: 1118885

The microscopic appearance of the stained wood is described. Confertobasidium olivaceoalbum was isolated from the wood and subsequent inoculation into heartwood and sapwood of lodgepole and southern yellow pines resulted in stained heartwood.

796. FILIP, G.M., GOHEEN, D.J. Tree mortality caused by root pathogen complex in Deschutes National Forest, Oregon.
Plant Disease, 1982, 66(3): 240-243
15 ref., 4 tab.
Subject Codes: N/A
CAB: 1536719

A survey of a severely infected 1 000 ha mixed conifer forest revealed that of trees more than or equal to 15 cm dbh, 11.1% (21.6% of merchantable wood) had been killed by root diseases during the preceding 20 years. Armillaria mellea occurred on all spp., Phellinus (Inonotus) weirii on Abies grandis and Pseudotsuga menziesii, Ceratocystis wageneri on Pinus ponderosa and P. contorta, and Fomes annosus (Heterobasidion annosum) on A. grandis. Two or more root pathogens frequently occurred in close association. This is the first report of C. wageneri on P. contorta in Ore., and of extensive infection of P. ponderosa by C. wageneri in the Pacific Northwest.

797. FILIP, G.M., SCHMITT, C.L. Susceptibility of native conifers to laminated root rot east of the Cascade Range in Oregon and Washington.
For. Sci., 1979, 25(2): 261-265
Subject Codes: 2.3
LISC: 428648

Of 6 native conifer species in eastern and central Oregon and Washington, USA, Tsuga mertensiana exhibited the most infection and mortality caused by Phellinus weirii, while Pinus contorta was least affected. Tree mortality was the most common indicator of infection in susceptible species. Internal decay (butt rot) was more common in disease- resistant species. Healthy trees in infected plots were exposed to large quantities of fungus inoculum as indicated by inoculum indices.

798. FLETCHER, R. Challenging dwarf mistletoe (Loranthaceae).

Forest Research: What's New in the West, 1977, January 12-15.
3 ref.
Subject Codes: 8.0
CAB: 1008426

A discussion of the possible value to foresters of 2 computer programs, SWYLD2 for south-western ponderosa pine (Pinus ponderosa) and LPMIST for lodgepole pine (Pinus contorta) in managing both mistletoe-infested and healthy forests. The programs have been devised to help decide on problems of thinning, rotation ages, harvesting methods, etc. and the only data needed are a few standard stand characteristics. An example is given to illustrate how the programs may be used.

799. HARVEY, A.E., MARTIN, N.E., WOO, J.Y. Diseases of reforestation seedlings in the central and northern Rocky Mountains.
Project INT-2206, Intermountain For. and Rge. Exp. Sta., Moscow, IDA, 01 Oct 79 to 30 Sep 84
Subject Codes: N/A
CRIS: 0045913

Objectives: Develop improved technology for reducing disease-related mortality of artificial and natural regeneration of forest lands in the intermountain west. Approach: The approach involves the integration and development of knowledge about the relations of pathogenic and non-pathogenic microbial activities that cause seedling mortality and loss of vigor throughout the first 5 years of establishment and growth in both natural and artificial reforestation stock. Progress: Established that soil organic materials are important centers of ectomycorrhizal activity and nonsymbiotic nitrogen fixation. Present results indicate organic materials in excess of 45% of the 12 in. of soil provide no additional benefits. Applicable to setting post-site preparation and prescribed burning standards for residue loading. Documented importance of fungus-bacteria associations in decay-activated nonsymbiotic nitrogen fixation in decomposing wood residues. Useful for establishing N-fixation rates in various types of woody residues including wood chip piles on the forest site. Demonstrated the effect of partial-cutting and clear-cutting on distribution of ectomycorrhizal activity in residual and adjacent soil systems. Applicable to applying specific cutting methods on sites which may be difficult to regenerate with conifers. Reported aspects of ultrastructure of Cronartium ribicola infections on alternate host (Ribes) plants that are applicable to interpretations of physical and chemical interactions between the host and parasite.

800. HAWKSWORTH, F.G. Dwarf mistletoe and its role in lodgepole pine ecosystems. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 342-358
37 ref.
Subject Codes: N/A
CAB: 757659

Discusses the biology and ecology of Arceuthobium americanum, a primary parasite of Pinus contorta, and its adverse effects on timber resources.

801. HAWKSWORTH, F.G., DIXON, C.S., KREBILL, R.G. 1983. Peridermium-bethelii a rust associated with lodgepole pine Pinus contorta dwarf mistletoe Arceuthobium americanum. Plant Disease 67(7):729-733.

The rust fungus P. bethelii, which is associated with dwarf mistletoe (A. americanum) in lodgepole pine (P. contorta), has generally been considered synonymous with cronartium comandrae. P. Bethelii, however, differs in its smaller, less pyriform aeciospores, apparent lack of spermagonia, later aecial aporulation period, and constant association with dwarf mistletoe. Attempts to infect mistletoe-infected pines were either unsuccessful or inconclusive and potential alternate hosts were not found. Field evidence suggests the rust may be autoecious.

802. HAWKSWORTH, F.G., HINDS, T.E., JOHNSON, D.W., LANDIS, T.D. Silvicultural control of dwarf mistletoe in young lodgepole pine stands.
USDA For. Serv. Tech. Rep., Rocky Moutain Region, 1977, No. R2-10: 13 pp.
1 ref., 2 pl.
Subject Codes: N/A
CAB: 1055681

Dominance class, d.b.h. and degree of infestation with dwarf mistletoe (Arceuthobium americanum) were recorded for plots in 20-, 30-, or 40-year old stands of Pinus contorta in N. Colorado in 1965 and 1966, and in 1975. Strict sanitation was carried out by felling all visibly infected trees in 1965/66 and 1968/69. All treated plots and some plots free from mistletoe were thinned to 10 x 10' in 1970. In treated plots, 31.5% of trees were infected in 1965 and 21.1% in 1975. In untreated plots 27.9% of trees were infected in 1965 and 42.1% in 1975. The average d.b.h. increased by 1.5 and 0.7" in thinned and unthinned plots respectively. Basal area decreased by 53% in treated plots and increased by 76% in untreated plots. It is concluded that strict sanitation reduces stocking too much if more than 40% of trees are infected. Thinning to 10 x 10' was found to be too severe.

803. HAWKSWORTH, F.G., STALEY, J.M., HINDS, T.E. Forest diseases of the Rocky Mountains and the southwest.
Project RM-2205, Colorado State Univ., Fort Collins, COL, 17 Jun 68 to 24 Feb 86
Subject Codes: N/A
CRIS: 0000023

Objectives: To provide the technology to quantify losses from diseases and develop integrated pest management strategies for selected tree diseases. Disease damage data need to be quantified for integration into yield simulation models for Integrated Pest Management strategies. Approach: The research will involve developing yield models for dwarf mistletoes, comandra rust and root diseases. The recently approved dwarf mistletoe program involving all 4 western stations will be a major effort on this problem. Techniques to evaluate the Integrated Pest Management strategies to ameliorate effects of diseases on recreational and aesthetic values of high-use forests are not available. This research will concentrate on wrapping up 25 years of research of aspen diseases particularly as they relate to recreational forests. Progress: (80/10 81/09) Preliminary studies indicate that photochemical air pollution along the Colorado Front Range is causing little or no damage to native ponderosa pine stands. Trees have been tagged to monitor long- term effects. Effective chemical controls have been developed to minimize damage due to needle cast fungi in Scotch pine Christmas tree plantations in the Pacific Northwest. Losses of lodgepole pine due to dwarf mistletoe were found to be nearly 10 million cubic feet per year in the National Forests of Colorado and Wyoming. Although dwarf mistletoe is locally damaging to bristlecone pine on the San Francisco Peaks, Arizona, the parasite is not a threat to the small bristlecone pine stands. Studies were continued to develop and refine yield simulation prorams for mistletoe infested stands in the west and to apply them under Mexican forest conditions. Ponderosa pines which were bred for mistletoe resistance at the Fremont Experimental Forest, Colorado, were found to show no resistance to mistletoe.

804. HAYES, A.J. The occurrence of Crumenula sororia Karst. on lodgepole pine in the United Kingdom.
Forestry, 1973, 46(2): 125-128
21 ref.
Subject Codes: N/A
CAB: 249492

Describes the processes of infection, lesion and canker development, on the basis of an anatomical study of 10 infected and 10 uninfected trees of Pinus contorta felled at 43 years old in Kincardineshire, Scotland. After infection, tracheid length and diameter decreased significantly but the mean height of rays increased, and this was associated with a greater proportion of tall rays and also more numerous and wider resin ducts. A comparison is made with infection in P. nigra var. maritima, in which the fungus depends on wounds for entry, whereas it may be a primary pathogen on P. contorta. Although relatively harmless, appreciable increment losses occur when many cankers develop on the same tree, and the importance of this pathogen should not be overlooked.

805. HAYES, A.J. The mode of infection of lodgepole pine by Crumenula sororia Karst. and the susceptibility of different provenances to attack.
Forestry, 1975, 48(1): 99-113
15 ref.
Subject Codes: N/A
CAB: 471983

In continued work, experimental inoculations with mycelial cultures of C. sororia were made on wounded and unwounded shoots of 1 + 1 transplants of Pinus contorta

grown in pots in a greenhouse. After 9 months, 25% of inoculations on unwounded shoots and 40- 60% of inoculations on wounded shoots produced successful infections; after 16 months these differences disappeared. Current year's shoots were more resistant than 1-year- old shoots to infection. The virulence of the five strains of C. sororia differed. Significant variation in susceptibility of P. contorta occurred, even among provenances geographically close together; the most susceptible and most resistant provenances from British Columbia were adjacent to each other.

806. HAYES, A.J. Incidence and importance of Crumenula sororia on lodgepole pine.
European Journal of Forest Pathology, 1977, 7(2): 105-119
19 ref.
Language: en
Summary Languages: fr, de
Subject Codes: 1.4
CAB: 762935

The percentage of Pinus contorta trees from eleven sources in North America that were infected with C. sororia in Scotland varied with provenance and with the climatic zone where grown in Scotland. Material from four sources differed in the pattern of degree of infection with altitude, aspect, and degree of exposure.

807. HAYES, A.J. Effect of tree vigour on the infection of lodgepole pine by Crumenula sororia Karst.
Scottish Forestry, 1978, 32(4): 259-270
Subject Codes: N/A
LISC: 245758

In stands of lodgepole pine of Alberta provenance growing in eastern and northern Scotland (which had developed a mature canopy structure at least 30 years old), 53% of stems in Climatic Zone A, characterized by a relatively short growing season, and 81-100% of stems in Climatic Zones B and C, were infected by C. sororia. Crops of Shuswap Lake provenance of similar age growing in the same localities were 54% and 70-78% infected, respectively. Infection incidence in trees which differed in vigour as measured by crown classification was significantly related with site elevation only in Shuswap Lake crops growing above 500 m a.s.l. Significantly less infections occurred on older dominant trees of Alberta provenance planted on the cooler N. aspect whereas on other aspects the incidence of infection differed among the subdominants. Infection incidence on trees planted in different exposure regimes differed only for the most exposed Alberta crops where significantly more infections occurred on subdominant trees. The evidence suggests that tree vigour as expressed by crown classification is important in determining infection incidence in C. sororia only under extreme site conditions.

808. HAYES, A.J. Spore liberation in Crumenulopsis sororia.
Trans. Br. Mycol. Soc., 1980, 74(1): 27-40
Subject Codes: N/A
LISC: 460471

C. sororia spores were trapped in lodgepole pine (Pinus contorta) forests in eastern Scotland from June to October in 1970 and 1971. The concentration of spores in the atmosphere showed a marked diurnal periodicity, peak numbers occurring from 0.600 to 12.00 h. Spore discharge ceased at temperatures greater than 16 deg. C and at r.h. less than 65%. A substantial triggering effect was demonstrated both on a diurnal and on a periodic basis, relative humidity, net incoming radiation and rainfall less than or equal to 24 h previously affecting spore release. Atmospheric spore concentration was also related to the climatic regime occurring less than or equal to 24 h following discharge.

809. HAYES, A.J., MANAP AHMAD, A. The infection of Corsican pine by Crumenula sororia Karst.
Forestry, 1975, 48(2): 183-191
12 ref.
Subject Codes: N/A
CAB: 564685

Describes studies in vitro of the germination of ascospores of C. sororia.

Results showed that free moisture was required and that the optimum temperature for germination was 20-25 deg C. Aqueous extracts of bark and wood of Corsican Pine and of bark of lodgepole pine inhibited spore germination. Inoculation experiments showed that spores or hyphae of C. sororia invaded tissues of 2-year-old Corsican Pine only through wounds made with a scalpel or by removal of a needle fascicle. In field inoculation experiments, different isolates differed significantly in pathogenicity. Infections were more severe on 4-year-old than on 1-year-old branches.

810. HAYES, A.J., NEWTON, N.G., et al Incidence and importance of Crumenula sororia Karst. in eastern and northern Scotland.
Scottish Forestry, 1975, 29(4): 274-304
9 ref.
Subject Codes: N/A
CAB: 546705

Reports a survey during 1970-72 of the incidence of C. sororia on 57 200 Pinus contorta trees of various provenances in 953 compartments in UK Forestry Commission forests in N. and E. Scotland. The susceptibility of the provenances varied in each of Fairbairn's climatic zones. A progressive increase in the number of cankers was noted in passing from zone A through zone B to zone C, but the degree of infection suggested that C. sororia is a weak pathogen. Severity of infection was negatively related to altitude in zone A, but positively related in zones B and C. Stage of infection and exposure were positively related, but in general little discernible relation was seen between exposure and severity of infection. Major provenances of P. contorta are recommended for planting in each climatic zone.

811. HAYES, A.J., NEWTON, N.G., JOLLY, G.M., WOOD, J., ANDERSON, M.H. The prediction of Crumenulopsis sororia (Karst.) Groves. Incidence on lodgepole pine (Pinus contorta Dougl.) using multiple regression techniques.
European Journal of Forest Pathology, 1981, 11(7): 396-411
46 ref., 6 fig., 7 tab.
Language: en
Summary Languages: fr, de
Subject Codes: N/A
CAB: 1511989

The investigation included 57 forests (953 compartments) in N and E Scotland. Using a simple climatic zone division, a significant relationship between percentage infection on whorls 1-5, 6-10 and 11-15 and elevation, exposure and site aspect was demonstrated, whereas severity of infection was not well related with these variables in any of the models tested. This suggests that severity may be influenced by other independent variables such as persistence of liquid water on bark, success of spore germination and host resistance. This approach offers an opportunity to predict possible susceptibility of different provenances under specific site conditions.

812. HIRATSUKA, Y. 1987. Forest tree diseases of the prairie provinces. Can. For. Ser North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-286. 136 p.

The major forest tree diseases of the Canadian prairie provinces are described in terms of their cause, distribution and hosts, symptoms and signs, disease cycle, damage, and control. The 25 conifers, 15 deciduous, and 6 noninfectious disorders illustrated by 47 pages of color photographs. An appendix listing the diseases by host, a glossary of technical terms, and a general index listing the common and scientific names of the hosts and the scientific names of the pathogens are also included.

813. HIRATSUKA, Y., FUNK, A. Additional records of Gremmeniella abientina in western Canada.
Plant Disease Reporter, 1976, 60(7): 631
5 ref.
Subject Codes: N/A
CAB: 687602

Reports the occurrence of G. abientina in both the perfect and imperfect state on trees of Pinus contorta var. latifolia in and around the area in Jasper National Park, Alberta. The fungus was also identified on P. albicaulis and P. ponderosa in separate areas of British Columbia. It is thought that G. abientina is indigenous to western Canada since introduction on nursery stock is unlikely;

symptoms are inconspicuous and it was discovered in widely separated areas. The need is emphasized for thorough checking in nurseries and plantations.

814. HIRATSUKA, Y., TSUNEDA, A., SIGLER, L. Occurrence of Scytalidium-uredinicola new-record on Endocronartium-harknessii in Alberta, Canada.
Plant Dis. Rep., 63(6): 512-513
Subject Codes: N/A
BIO: 68058695

A mycoparasite, S. uredinicola, was recognized in Alberta, Canada, on the western gall rust fungus E. harknessii on Pinus banksiana and P. contorta. This is a new host record for S. uredinicola and the 1st record of this fungus in Canada.

815. HOBBS, S.D., PARTRIDGE, A.D. Wood decays, root rots, and stand composition along an elevation gradient.
Forest Science, 1979, 25(1): 31-42
25 ref.
Subject Codes: N/A
CAB: 1071789

Wood-decaying fungi were examined in 74 randomly selected stands of mixed conifers (Abies grandis, A. lasiocarpa, Larix occidentalis, Picea engelmannii, Pinus albicaulis, P. contorta, P. monticola, P. ponderosa, Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla, T. mertensiana) in northern Idaho in 1974 and 1975. Stands were ordinated 2-dimensionally with Cornell Ecology Programs based on the presence of all vascular plants, and the ordination approximated to an elevation gradient. The stands were classified into discrete units, based on the presence of coniferous trees, by an agglomerative cluster analysis. Fungal distributions and stand composition changed with increasing elevation: Armillariella mellea and Echinodontium tintorium were found throughout the area, with the latter more frequent in stands dominated by Abies grandis; Phaeolus schweinitzii, Inonotus tomentosus, and Perenniporia subacida were found more often above alt. 1 500 m; Polyporus sericeomollis and Phellinus weirii were found below alt. 1 500 m and primarily on Thuja plicata; and Phellinus pini was also found most frequently at these altitudes. Other infrequently found fungi are tabulated, with hosts and clusters.

816. HOCKING, D. Effect and characteristics of pathogens on foliage and buds of cold stored white spruce and lodgepole pine seedlings.
Can. J. For. Res., 1971, 1(4): 208-215
Subject Codes: N/A
BIO: 53068908

817. HOFFMAN, J.T., HOBBS, E.L. 1985. Lodgepole pine dwarf mistletoe arceuthobuim americanum in the intermountain region USA. Plant Disease. 69(5):429-431.

During 1978 and 1979, a survey of lodgepole pine dwarf mistletoe (A. americanum) was conducted in 11 national forests in Utah, Nevada, southern Idaho and western Wyoming. Incidence of the parasite by national forest ranged from 17-79% with a weighted mean of 60% of surveyed plots. Computer simulated yield information derived from survey data indicated that annual volume reduction of lodgepole pine (Pinus contorta) by dwarf mistletoe varies among national forests from 16,040 to 100,420 m3. The total timber volume yield reduction caused by lodgepole pine dwarf mistletoe in the intermountain region is estimated at 488,120 m3/yr.

818. HOPKINS, J.C. Control of Atropellis canker of lodgepole pine.
Proc. Can. Phytopathol. Soc., 37, 1971: 17
Subject Codes: N/A
BIO: 73023439

819. HUNT, K., KUECHLER, A. Chemical analysis of Atropellis-piniphila canker infected lodgepole pine.
Can. Dep. Fish, Forest, Bi-monthly Research Notes, 26(6), 1970: 59
Subject Codes: N/A
BIO: 71035670

820. HUNT, R.S. Slugs feeding on Cronartium in British Columbia.
Pac. For. Res. Centre, Victoria, B.C., Canada, Bi-monthly Research Notes, 1978, 34(4): 21
1 pl.
Subject Codes: N/A
CAB: 1118938

On Pinus contorta 10 or more slugs were frequently found feeding on C. comptoniae cankers in the early morning or on wet days. On warm days slugs were found under the litter and occasionally under exfoliating bark of E. harknessii galls. Germination of E. harknessii and C. comptoniae aeciospores egested by P. andersoni was obtained in water droplets and on water agar. It is suggested, nevertheless, that slugs probably reduce the inoculum potential of rusts, but that their feeding wounds provide infection courts for secondary fungi.

821. HUNT, R.S. Pine needle casts and blights in the Pacific regions.
Dep. Envionment, Can. Forest Serv., Pac. For. Res. Cen., Victoria, B.C. FPL 43 (revised), 1981: 7 pp.
Subject Codes: N/A
RCA: X1143

822. ILLINGWORTH, K. Variation in the susceptibility of lodgepole pine provenances to sirococcus shoot blight.
Canadian Journal of Forest Research, 1973, 3(4): 585-589
Language: en
Summary Languages: fr
Subject Codes: 1.4
CAB: 445246

Marked variation in susceptibility to S. strobilinus was noted among the 153 Pinus contorta samples.

823. JACOBI, W.R. Management of lodgepole pine infested with comandra blister rust in the Rocky Mountain region.
Project COL00506, Colorado State Univ., Fort Collins, COL, 01 Oct 81 to 30 Sep 83
Subject Codes: 5.2, 7.0
CRIS: 0084811

Objectives: In cooperation with the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station and U.S. Forest Service, Forest Pest Management, Region 2 this project will: evaluate the distribution and ecology of Cronartium comandrae within the lodgepole pine forests of Colorado and Wyoming; determine the relationships between disease severity and the growth, survival, and quality of lodgepole pine; and provide resource managers with interim decision models and guidelines to determine the potential yield of infested stands under various alternative silvicultural treatments. Approach: Information on the ecology and distribution of rust will be assembled from published literature, forest inventories, stand examinations, pest detection reports and previous comandrarust studies. Additionally, transects will be run throughout infested stands along with a statistical survey of randomly-located quadrats to estimate proportion of individual tree damage, branch canker expansion and the influence of rodents on stem and canker expansion. Sample quadrats will be established in multi-aged stands with different disease severities.

824. JACOBI, W.R. Hazard-rating and ecology of comandra blister rust in the Rocky Mountain region.
Project COLZ00501, Colorado State Univ., Fort Collins, COL, 01 Oct 82 to 20 Sep 85
Subject Codes: N/A
CRIS: 0088511

Objectives: In cooperation with the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, local National Forests and U.S. Forest Service, Forest Pest Management, Region 2, this project will: Determine methods for predicting the occurrence of comandra blister rust infestations in the lodgepole pine forests of the Rocky Mountain Region, evaluate the ecological relationships between the distribution and biology of comandra rust on lodgepole pine and the alternate host Comandra umbellata. Approach: Field data on disease incidence and

site factors will be collected in Colorado and neighbouring states during three summers utilizing permanent and non-permanent plots in infected and non-infected stands to determine methods of hazard rating. Sample transects with random sample plots and mapping of the lodgepole pine and comandra habitats will be employed to determine the association or aggregation of lodgepole pine and C. umbellata. Hazard rating information will be summarized in guidelines especially useful to forest managers until incorporated into a formal program.

825. JOHNSON, D.W. Growth and development of Comandra rust cankers on young lodgepole pine.
Plant Disease Reporter, 1979, 63(11): 916-918
Subject Codes: N/A
CAB: 1147024

Data are presented from a study of 49 rust - (Cronartium comandrae) infected trees (15-yr-old in 1973) in 9 circular plots (0.0004 ha) in the Shoshone National Forest, made between 1973 and 1979. Average growth rate of branch cankers was 1.8 cm/yr and 95% were within 1 m of the ground. Mortality of trees was 23.4%, and during the study active branch and stem infections respectively decreased by 56% and 42%, while inactive branch infections increased by 262%. It is suggested that pruning branch cankers within 22 cm of the stem may reduce stem infection of high value trees.

826. KAMP, B.J. VAN DER, HAWKSWORTH, F.G. 1985. Damage and control of the major diseases of lodgepole pine. Pages 125-131 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

The most important diseases of lodgepole pine in decreasing order of damage are dwarf mistletoe (Arceuthobium americanum Nutt), the stem rusts [Cronartium spp. and Endocronartium harknessii (J.P. Moore) Y. Hirat.], a group of root diseases, and finally, cankers and foliage diseases. Dwarf mistletoe, a vascular parasitic plant, causes increment losses which become more severe with time since infection and finally results in decline and death of the host. Control requires even-aged management with eradication of the parasite at harvest plus provisions to prevent or retard reinvasion from stand edges. Severe damage by the pine stem rusts is limited to a relatively narrow range of ecological conditions. For some species and regions these have been identified. Management involves and adjustment of stocking to provide for increased mortality, using as a guide locally measured rates of mortality. Resistance is at least in part controlled genetically, and tree improvement programs should take rust resistance into account. Root diseases are locally damaging. Most can survive on dead root systems, so that the infected area becomes non-productive. Management requires the use of resistant species or destruction of the inoculum by stump and root extraction or fumigation. Cankers and foliage diseases can cause local damage. Direct control measures are either not available or not recommended. Damage in most cases is limited to temporary increment loss or, in the case of cankers, deformation of the bole and breakage.

827. KARLMAN, M. Fungal diseases in Pinus contorta.
Skogen, 1976, 63(15): 628-630
Language: sv
Subject Codes: N/A
CAB: 796279

The existing or potential susceptibility of the species to fungus diseases in Sweden is briefly discussed and observations in various trial plots and stands are described. These include a disease characterized by bark lesions and heavy resin flow, tentatively attributed to Crumenulopsis sororia. Other, possibly pathogenic, fungi found on the affected trees were a Dasyscypha sp. new to conifers in Sweden, Sydowia polyspora with its imperfect stage Sclerophoma (Dothichiza) pithyophila, and Tympanis confusa. It is pointed out that most fungus diseases were observed in southern or central Sweden; in northern Sweden most attacks were associated with the choice of unsuitable (too southerly) provenances.

828. KARLMAN, M. 1984. Pathogens and other threats to Pinus contorta in northern Sweden. University of Umea, Department of Ecological Botany, Umea, Sweden.

This doctoral dissertation is a summary and discussion of the following two papers, I. Karlman, M. 1981. The introduction of exotic tree species with

special reference to Pinus contorta in northern Sweden. Review and background. - Studia Forestalia Suecica 158. 25 pp. II. Karlman, M. 1984. Pathogens and other threats to Pinus contorta in northern Sweden.

829. KRAMER, C.L. Mycological investigations of parasitic fungi.
Project KAN00266, Kansas State Univ., Manhattan, KAN, 10 Jul 47 to 30 Sep 79
Subject Codes: N/A
CRIS: 0029106

Objectives: Identify and determine the distribution of parasitic fungi of agronomic and horticultural crops. Study the life histories of parasitic fungi in relation to their control. Study the nature of resistance of economic crops to diseases. Study the fungus and bacterial parasites of the fungi causing rust, smut, and other diseases of economic importance. Determine the number, type and time of appearance of spores in the air. Approach: During the spring, summer and fall, trips are made throughout the State, collecting fungi and diseased plant materials. These are brought into the laboratory where isolations are made if necessary, identified, processed and filed in the herbarium for future reference. These collections are then studied intensively by groups, annotated according to the latest concepts with manuscripts containing keys and descriptions for the Kansas species of each major group of fungi. In addition to making personal collections, diseased specimens are often sent in by country agricultural agents and other interested persons throughout the state. Progress: In September, 1976, a study was begun of airborne fungal spores and pollens that is hoped to be of use to practicing allergists and to plant pathologists. For plant pathologists, this information should help in interpreting collections from spore sampling studies of airborne plant pathogens. This 5-year study is now completed and data is presently being analyzed. Six papers are anticipated from this study. A NSF research grant has been awarded.

830. KREBILL, R.G. Cronartium-comandrae in the Rocky Mountain states, USA - lodgepole pine.
US Forest Serv. Research Paper, INT-50, 1-26: 1968
Subject Codes: N/A
BIO: 50066949

831. KREBILL, R.G. Lodgepole pine's fungus-caused diseases and decays. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 377-405
70 ref.
Subject Codes: N/A
CAB: 757662

A review of the fungal disease of Pinus contorta is presented. Their implications for forest management are discussed.

832. LAINE, L. The occurrence of Heterobasidion annosum (Fr.) Bref. in woody plants in Finland.
Metsantutkimuslaitoksen Julkaisuja, 1976, 90(3): 53 pp.
89 ref., 6 pl.
Language: en
Summary Languages: fi
Subject Codes: N/A
CAB: 1071784

Results from field studies show that the fungus is a serious pathogen of pine (Pinus sylvestris) as well as spruce (Picea abies) and also occurs on Betula pendula, B. pubescens, Alnus incana and Juniperus communis in infected pine stands. It was also observed on Populus tremula, Sorbus aucuparia and some ericaeous shrubs; and in some plantations of 14 exotic species.

833. LONGO, N., MORIONDO, F., LONGO, B.N. Some aspects of biology of Melampsora pinitorqua Rostr. in Italy, also compared to other European countries.
Phytophathol. Mediterr., 1980, 19: 30-34
Language: en
Summary Languages: it

Subject Codes: N/A
LISC: 603552

Some of the present subjects of research on biology of M. pinitorqua in Italy, Finland, Poland and Sweden are the following: (1) Susceptibility of various pine species in different environments; (2) Trials for better identification of different species of the M. poulnea "complex"; (3) Overwintering and germinability of the rust teliospores. In all countries Pinus contorta and P. banksiana appeared not susceptible, P. sylvestris was the most susceptible species, P. nigra ssp austriaca, somewhat susceptible in Italy, appeared more susceptible in Sweden and Finland, but to a clearly lower degree than P. sylvestris. The importance of phenology in relation to infection on P. nigra is discussed. The second point of the research deals with the Italian trials for better identification of 2 species of Melampsora, M. pinitorqua from Tuscany and M. larici-tremulae from the central Alps.

834. LOWE, D.P. Needle rust of lodgepole pine.
Pest Leaflet, Forest Insect and Disease Survey, Canada, 1972, No. 41, 7 pp.
7 ref.
Subject Codes: N/A
CAB: 098487

Presents notes on Coleosporium asterum, its hosts, life cycle, symptoms of attack, etc. Control is probably desirable only in Christmas-tree plantations and nurseries where minor needle-cast and discoloration of the foliage are important; trees are rarely killed. An important measure is the eradication of the secondary hosts (asters and goldenrods) from the neighbourhood of the trees.

835. LOWE, D.P., ZILLER, W.G. Stem rusts of pine in western Canada.
Can. For. Service, Pacific For. Res. Centre, For. Pest. Leaflet 37, 1977: 10 pp.
Subject Codes: N/A
BIO: 78055142

836. MCCAULEY, K.J., COOK, S.A. Phellinus weirii infestation of two mountain hemlock forests in the Oregon Cascades.
Forest Science, 1980, 26(1): 23-29
13 ref.
Subject Codes: 2.3
CAB: 1286351

A study of infection by P. (Inonotus) weirii in 2 coniferous stands (alt. 1650 m). Number, species, age, and circumference at b.h. of trees were obtained in transects of 3 infection centres per stand. Resistant trees (not killed, or killed slowly) were discriminated by size and age from adjacent regrowth trees. The rate of spread of I. weirii and relative resistance of trees on the basis of escape frequency was determined at 10 infection centres in each stand. I. weirii spread vegetatively at 23 cm/yr in a mixed mountain hemlock (Tsuga mertensiana)/other conifer stand and 34 cm/yr in a less diverse stand dominated by mountain hemlock. The order of resistance from most to least was western white pine (Pinus monticola), lodgepole pine, Pacific silver fir (Abies amabilis), noble fir (A. procera), Engelmann spruce, and mountain hemlock. Successional tree vegetation that developed after passage of the advancing mycelium was more diverse than that being attacked. Reinfestation of successional trees occurred within infection centres after 88 to 165 yr. From authors' summary.

837. MANN, W.F. JR. Senna seymeria parasitizes western conifers.
Economic Botany, 1979, 33(3): 338-339
2 ref.
Subject Codes: 2.3
CAB: 1329648

Seymeria cassioides (a hemiparasitic weed attacking all 10 southern pines) was grown with 10 species of western conifers in greenhouse studies in 1976 and 1977. Haustorial attachments were found on the roots of all hosts, but were most numerous on pines, least on firs, and of intermediate numbers on spruce and cedar. In pines ht. of parasite was directly related to number of haustoria.

838. MARK, W.R., HAWKSWORTH, F.G., OSHIMA, N. Resin disease: a new disease of lodgepole pine dwarf mistletoe.
Canadian Journal of Forest Research, 1976, 6(3): 415-424
29 ref.
Subject Codes: N/A
CAB: 699333

The causes and symptoms of the disease and its effectiveness for the control of the host Arceuthobium americanum were studied throughout the host range on Pinus contorta from Idaho to Colorado. Inoculation of A. americanum with 10 species of fungi (isolated from resin disease cankers) showed the most important causal agents to be Aureobasidium pullulans and Alternaria alternata. Histological studies indicate that the primary effect of the disease is the formation of a necrophylactic periderm in the host bark, isolating the shoots from the sinkers and killing the mistletoe tissue exterior to the periderm. Natural resin disease was studied over a 14-year period in a Pinus contorta stand in Colorado where up to 97% of mistletoe cankers were infected with the disease, without apparent damage to the stand. It is concluded that resin disease is dwarf mistletoe.

839. MARTINSSON, O. Stem rusts in lodgepole pine provenance trials.
Silvae Genetica, 1980, 29(1): 23-26
8 ref.
Language: en
Summary Languages: de
Subject Codes: 1.4
CAB: 1343483

The incidence of 3 species of stem rust - Cronartium coleosporiodes, C. comandrae and Endocronartium harnessii - was studied in provenance trials in British Columbia and the Yukon territory, Canada in 1978. Considerable differences in susceptibility were found between provenances and between progenies within provenances. The av. incidence of trees infected in the main plantation was 22%; in some provenances 50% of the trees were infected, many seriously, and several trees were killed. From author's summary.

840. MARTINSSON, O. Impact of western gall rust in natural stands of lodgepole pine.
Prepared for: Workshop on Genetics of Host-Parasite Interactions in Forestry - Proceedings, Wageningen, Sept. 14-21, 1980: 4 pp.
Subject Codes: N/A
RCA: X1031

841. MARTINSSON, O. How dangerous are the North American pathogens to the Scandinavian lodgepole pine? IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 257-262
9 ref.
Subject Codes: N/A
RCA: X1090

This paper reviews the most destructive pathogens of lodgepole pine within its natural range and discusses the risks of transferring these native diseases to Europe.

842. MIELKE, M.E. Pathogenicity of Verticicladiella penicillata (Grosm.) Kendrick to northern Idaho conifers.
Forest Science, 1981, 27(1): 103-110
25 ref.
Subject Codes: 2.3
CAB: 1395412

V. penicillata isolated from roots of ponderosa pine was used to inoculate roots of 10 lodgepole pines, 11 ponderosa pines, 5 Douglas-firs, 5 grand firs (Abies grandis) and 10 western larches (Larix occidentalis) of d.b.h. 5.8-30.5 cm and 9-83 years old, in the University of Idaho experimental forest. Inoculations were made in May and June, 1978 using colonized matchsticks or medium placed in core holes; control roots were similarly treated without incoulum. After 120 to 160 days all species became infected but characteristic black stain was not observed

in lodgepole or ponderosa pines and only infrequently in grand fir. No trees were killed as a result of infection during the test period. V. penicillata hyphae were concentrated in the tracheids, passing from one to another by hyphal branching through bordered pit pairs. There was resin occlusion of all xylem elements, particularly ray cells. No direct lysing of tracheid walls was seen.

843. MILLAR, C.S., MINTER, D.W. Lophodermella-sulcigena.
CMI (Commonw. Mycol. Inst.), Descr. Pathog. Fungi Bact., 1978, 57(561-570): 562 pp.
Subject Codes: N/A
BIO: 16023121

844. MINTER, D.W., GIBSON, I.A.S. Davisomycella-ampla.
CMI (Commonw. Mycol. Inst.), Descr. Pathog. Fungi Bact., 1978, 57(561-570): 561 pp.
Subject Codes: N/A
BIO: 16023120

845. MINTER, D.W., MILLAR, C.S. Lophodermium-conigenum.
CMI (Commonw. Mycol. Inst.), Descr. Pathog. Fungi Bact., 1978, 57(561-570): 565 pp.
Subject Codes: N/A
BIO: 16023124

846. MORRISON, D.J., HUNT, R.S. 1985. Blackstain root diseases on lodgepole pine Pinus contorta in British Columbia, Canada. Phytopathology. 75(1):1295.

847. MUIR, J.A. Dwarf mistletoe spread in young lodgepole pine stands in relation to density of infection sources.
Can. Dep. Fish, Forest, Bi-monthly Research Notes, 1970, 26(5): 49
Subject Codes: N/A
BIO: 71015578

848. MUIR, J.A. Increase of dwarf mistletoe infections on young lodgepole pine.
Canadian Journal of Forest Research, 1972, 2(4): 413-416
17 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 114323

Field studies in S. Alberta revealed a rapid increase in the incidence of Arceuthobium americanum in young Pinus contorta var. latifolia. In 10 areas of infected trees, the number of infections increased exponentially at a mean rate (base 10 logarithm) of 0.24 per year. Differences in rates of increase among areas were not significant.

849. MUIR, J.A. Lodgepole pine dwarf mistletoe on Douglas-Fir in Alberta.
Bi-monthly Research Notes, 1973, 29(4): 25-26
Subject Codes: N/A
CAB: 235010

Describes the occurrence of Arceuthobium americanum (lodgepole pine dwarf mistletoe) on a young Douglas-fir surrounded by young lodgepole pine infested with mistletoe.

850. MUIR, J.A. Effects of the fungal hyperparasite Colletotrichum gloeosporiodes of dwarf mistletoe Arceuthobium americanum on young lodgepole pine.
Can. J. For. Res., 1977, 7(4): 579-583
Language: en
Summary Languages: fr
Subject Codes: N/A
LISC: 056801

Dwarf mistletoe (A. americanum Nutt. ex. Engelm.) infected by the fungus C. gloeosporioides Penz. sensu von Arx was examined in 2 areas of young lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in southwestern Alberta. The fungus infected 35% and 75% of the dwarf mistletoe plants, 6% and 54% of the aerial shoots, and 7% and 8% of the berries in the respective areas. The number of dwarf mistletoe berries and maximum shoot lengths of dwarf mistletoe plants were significantly reduced by the fungus and dead plants were more frequent than in areas where the fungus was absent. However, numbers of new dwarf mistletoe plants were not significantly reduced by the fungus. Evidently future increase in numbers of dwarf mistletoe plants and eventual damage to young lodgepole pine in the areas will not be significantly decreased by the fungus.

851. MUIR, J.A. Dwarf mistletoe seed dispersal and germination in southwestern Alberta.
Can. J. For. Res., 1977, 7(4): 589-594
Language: en
Summary Languages: fr
Subject Codes: N/A
LISC: 042302

In 1966, numbers of seeds of dwarf mistletoe (Arceuthobium americanum) dispersed from 2 transplanted lodgepole pine (Pinus contorta var. latifolia) decreased logarithmically with increasing distance from the trees. In 2 study areas in 1967-69, dispersal of seeds from individual plants began in late August and was completed in 2-3 weeks. Differences of up to 2 weeks in the beginning and duration of dispersal were apparent between the areas. On one occasion, a difference in seed dispersal was noted between plants originating from seed collected at the 2 study areas and growing on a single tree at another location. Seed germination began in middle to late April, and in 4 to 6 weeks, 10-50% of the seed had germinated.

852. NICHOLLS, T., HAWKSWORTH, F., MERRILL, L. 1984. Animal vectors of dwarf

in lodgepole pine. American Journal of Botany. 71(5 part 2):59.

853. PAWSEY, R.G. Cronartium-comptoniae, a potential threat to pinus-contorta in Britain.
Forestry 1974, 47(1): 89-91
2 ref., 2 pl.
Subject Codes: N/A
CAB: 380562

Describes C. comptoniae (a heteroecious rust fungus with Pinus spp. and Myricaceae as alternate hosts), symptoms of infections, and the damage caused. This fungus has not yet been recorded in Britain, but causes considerable economic loss in North America. It seems unlikely that the disease could be eliminated once it had been introduced and become established, and forests in north-western Britain planted with Pinus contorta on sites where Myrica gale is native would be particularly susceptible.

854. PIIRTO, D.D., CREWS, D.L., TROXELL, H.E. The effects of dwarf mistletoe on the wood properties of lodgepole pine.
Wood and Fiber, 1974, 6(1): 26-35
20 ref.
Subject Codes: 1.3, 2.10
CAB: 514630

The properties of the wood of Pinus contorta from non-infected trees and of the infected and non-infected wood from trees infected with Arceuthobium americanum were compared. Measurements were made of bending strength, sp. gr., alcohol/benzene extractives, longitudinal shrinkage, % late wood, fibril angle, tracheid length and tracheid orientation. Detailed results are given in tables. Both infected and non- infected wood from the same tree were inferior to wood from non-infected trees in strength and longitudinal shrinkage characteristics.

855. POWELL, J.M. Incidence and effect of Tuberculina-maxima on cankers of the pine stem rust Cronartium-comandrae.
Phytoprotection, 1971, 52(3): 105-111
Subject Codes: N/A
BIO: 53033541

856. POWELL, J.M. Fungi and bacteria associated with Cronartium-comandre on lodgepole pine in Alberta.
Phytoprotection, 1971, 52(2): 45-51
Subject Codes: N/A
BIO: 53016322

857. POWELL, J.M. Occurrence of tuberculina-maxima on pine stem rusts in western Canada.
Can. Plant Dis. Surv., 1971, 51(2): 83-85
Subject Codes: N/A
BIO: 52138772

858. POWELL, J.M. Seasonal and diurnal periodicity in the release of Cronartium comandrae aeciospores from stem cankers on lodgepole pine.
Canadian Journal of Forest Research, 1972, 2(2): 78-88
32 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 114350

859. POWELL, J.M. Environmental factors affecting germination of Cronartium comandrae aeciospores.
Canadian Journal of Botany, 1974, 52(3): 659-667
26 ref.
Subject Codes: N/A
CAB: 371870

Studies were made on dry aeciospores collected from individual, sporulating pustules on Pinus contorta var. latifolia, in the Foothills and Rocky Mts. areas of Alberta. Aeciospores germinated over the temperature range 1 deg -30 deg C but germination was poor except in the range 5 deg -22 deg; the optimum temperature was 15 deg. Some aeciospores germinated after 1 hour of incubation and most germinated within 4 - 5 hours. Free water was apparently necessary for germination. Hydration of spores improved germination initially, but prolonged hydration decreased it. Aeciospores germinated well in the light and in the dark, but not in direct sunlight. Results are compared with those reported for other Cronartium rusts.

860. POWELL, J.M. Additional note on the incidence of Cronartium coleosporioides f. album on lodgepole pine.
Plant Disease Reporter, 1975, 59(1): 32-34
7 ref.
Subject Codes: N/A
CAB: 451531

A study was made from 1963 to 1972 of 56 cankers of white-spored C. coleosporioides on Pinus contorta var. latifolia in Alberta. Some new cankers were formed during this period. Of the 23 cankers originally studied in 1963, six were still sporulating in 1972, and two of these had sporulated in each year. By 1972, 60% of the cankers were dead.

861. POWELL, J.M. Arthropod taxa common to Cronartium cankers and the forest litter layer.
Bi-monthly Research notes, 1975, 31(4): 23
2 ref.
Subject Codes: N/A
CAB: 546703

In studies in SW Alberta, 42 arthropod taxa found in association with the forest litter at the base of Pinus contorta var. latifolia trees infected with Cronartium comandrae and with the cankers themselves are named, and the relations of certain species with their environment are summarized. The arthropods are

listed according to the habitat in which they were found.

862. POWELL, J.M., HIRATSUKA, Y. Serious damage caused by Stalactiform blister rust and western gall rust to a lodgepole pine plantation in central Alberta.
Canadian Plant Disease Survey, 1973, 53(2): 67-71
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 390910

Cronartium coleosporioides and Endocronartium (Cronartium) harknessii have caused severe damage to Pinus contorta var. latifolia grown as Christmas trees and ornamental trees in a farm in Alberta. C. coleosporioides killed 80% of young trees in the nursery and one-third of the transplanted stock.

863. POWELL, J.M., SKALEY, L.S. Arthropods from forest litter under lodgepole pine infected with Comandra blister rust.
Info. Report, Northern For. Res. Centre, Canada, 1975, No. NOR-X-130: 33 pp. 21 ref.
Language: en
Summary Languages: fr
Subject Codes: 6.1
CAB: 471535

Thirty samples of surface litter were collected from under Pinus contorta trees infected by Cronartium comandrae at six locations in SW Alberta in 1969-70. The collection comprised 327 arthropod taxa (including several hitherto undescribed or not reported from N. America, Canada or Alberta); 16 orders were represented, but more than two-thirds of the arthropods belonged the the Acarina. Of the taxa collected, 42 had previously been recorded as associated with C. comandrae cankers. The most important of these taxa were the nitidulid beetle Epuraea obliquus and the flies Mycodiplosis spp., Paracacoxenus guttatus and Bradysia spp.; the first three of these had earlier been shown to be mycetobiont species.

864. RADDI, P., FAGNANI, A. Relative susceptibility to blister rust caused by Cronartium flaccidum of several species of pine.
European Journal of Forest Pathology, 1978, 8(1): 58-61
2 ref.
Language: en
Summary Languages: fr, de
Subject Codes: N/A
CAB: 903642

In a trial at Florence, Italy, 3- and 15-month-old seedlings of 23 species of 2- and 3- needled pines were experimentally inoculated with C. flaccidum. The results are summarized in a table. Most of the mediterranean species (Pinus brutia, P. halepensis, P. mugo, P. nigra, P. pinaster and P. pinea) were highly susceptible. Spotted seedlings of P. ponderosa contained only mycelium, and not pycnia or aecia of C. flaccidum in the needle and stem tissues. The other American exotic species seemed to be highly resistant to the fungus.

865. REDFERN, D.B. Infection of Picea sitchensis and Pinus contorta stumps by basidiospores of Heterobasidion annosum.
European Journal of Forest Pathology, 1982, 12(1): 11-25
36 ref., 7 fig., 6 tab.
Language: en
Summary Languages: fr, de
Subject Codes: N/A
CAB: 1517837

On inoculation Sitka spruce was generally less susceptible than lodgepole pine. Measurement of the cross-sectional area occupied by the fungus on each stump provided a more sensitive test of sp. susceptibility than assessment of the proportion of stumps infected. High rainfall may reduce infection. In some stumps, the fungus is confined to the lower stump tissues, its absence from the upper portion being due to replacement by other micro-organisms or to physical conditions preventing survival. In both spp., but more commonly in spruce, some stumps remain alive for at least 2 years. Infection stumps than in those which

die rapidly after felling. The viability of basidiospore suspensions was determined more accurately and rapidly on a selective agar medium than on conifer stem sections.

866. REDFERN, D.B. Forest pathology. Sirococcus strobilinus.
Report on Forest Research, Forestry Commission, UK, 1973: 100-101, 103
2 ref.
Subject Codes: N/A
CAB: 409480

Describes an experiment to infect Lodgepole Pine with laboratory cultures of S. strobilinus. Lesions formed when wound inoculations were made, and provenances from southern interior British Columbia were more susceptible than those from the northern Oregon coast.

867. REID, R.W., SHRIMPTON, D.M. Resistant response of lodgepole pine to inoculation with Europhium-clavigerum in different months and at different heights on stem.
Can. J. Bot., 1971, 49(3): 349-351
Subject Codes: N/A
BIO: 52086562

868. ROBINS, J.K., SUSUT, J.P. "Red belt" in Alberta.
Info. Report, Northern For. Research Centre, Canada, 1974, No. NOR-X-99: 6 pp.
6 ref.
Subject Codes: N/A
CAB: 419183

Describes and illustrates with colour photos the widespread occurrence and severity of 'red belt' damage (injury to the foliage, buds and bark of conifers, especially Pinus contorta, distributed in well defined bands along the foothills (and probably attributable to desiccation by hot dry winds in early spring while roots and stems are still frozen) in Alberta during 1971, and discusses major implications for forest succession, logging, fire hazard and wildlife. Ca. 14 000 acres of mature and immature P. contorta were killed in the Cadomin area alone.

869. ROLL-HANSEN, F. Fungi dangerous to Pinus-contorta with special reference to pathogens from north Europe.
Eur. J. For. Pathol., 1978, 8(1): 1-14
Subject Codes: N/A
BIO: 66042181

Several species of fungi, not present in Europe, might act as damaging parasites in plantations of lodgepole pine (P. contorta) in the Nordic countries if they were introduced. Examples of such potentially damaging North American fungi are Cronartium comptoniae, C. coleosporioides, Endocronartium harknessii, Atropellis piniphila, Lophodermella concolor and Davisomycella ampla. Lodgepole pine is immune or extremely resistant to the rust fungi. It is considerably more resistant than Scots pine (P. sylvestris) to Phacidium infestans and Lophodermium pinastri. Lodgepole pine is less resistant than Scots pine to Crumenulopsis sororia and Discella strobilina. The resistance of lodgepole pine to Armillariella mellea, Heterobasidion annosum and other rot fungi, Botrytis cinerea, Diplodia pinea, Gremmeniella abietina, Lachnellula spp., Lophodermella sulcigena, Potebniamyces coniferarum, Scirrhia pini, Sydowia polyspora and Tympanis confusa is discussed.

870. SCHAFFER, B., HAWKSWORTH, F.G., et al. Effects of comandra blister rust and dwarf mistletoe on cone and seed production of lodgepole pine.
Plant Disease, 1983, 67(2): 215-217
Subject Codes: 4.1
RCA: X1026

871. SCHAFFER, B., HAWKSWORTH, F.G., BEEMSTERBOER, P. Effects of dwarf mistletoe and vigor classes on electrical resistance in lodgepole pine.
Forest Science, March, 1983: 29(1)
Subject Codes: N/A

RCA: X1148

872. SCHARPF, R.F., PARMETER, J.R. et al. Proceedings of the symposium on dwar mistletoe control through forest management, April 11-13, 1978, Berkeley, California.
Gen. Tech. Rep., Pacific SW For. & Range Experiment Stn., 1978, No. PSW-31: (4) + 190 pp.
many ref., 4 pl.
Subject Codes: 7.1
CAB: 1299413

The symposium deals with the control of Arceuthobium spp. on conifers in western N. America. The 30 papers are grouped into sections on basic biology and ecology, control planning and decision-making, control operations (with emphasis on silvicultural methods), improving control by research and cooperation, and integration of control with forest management. Several of these papers are listed: Stewart, J.L. Overview of the dwarf mistletoe problem. Hawksworth, F.G. Biological factors of dwarf mistletoe in relation to control. Parmeter, J.R., Jr. Forest stand dynamics and ecological factors in relation to dwarf mistletoe spread, impact, and control; Drummond, D.B. Approaches to determining volume, losses due to dwarf mistletoe on a Westwide basis. Hadfield, J.S.; Russell, K.W. Dwarf mistletoe management in the Pacific Northwest. Hawksworth, F.G. Intermediate cuttings in mistletoe-infested lodgepole pine and southwestern ponderosa pine stands. Guthrie, P. Ecological bases for silvicultural prescriptions for control of dwarf mistletoe in lodgepole pine. Muraro, S.J. Prescribed fire - a tool for the control of dwarf mistletoe in lodgepole pine. Wicker, E.F. Refinement and quantification of data for regulating dwarf mistletoe populations: an ecosystems approach. Water, W.E. Integrating dwarf mistletoe control with forest management.

873. SHRIMPTON, D.M., WATSON, J.A. Response of lodgepole pine seedlings to inoculation with Europhium-clavigerum - a blue stain fungus.
Can. J. Bot., 1971, 49(3): 373-375
Subject Codes: N/A
BIO: 52086467

874. SHRIMPTON, D.M., WHITNEY, H.S. In vitro growth of two blue stain fungi into resinous compounds produced during the wound response of lodgepole pine.
Pac. FRC, Can. For. Serv., Victoria, B.C. Bi-monthly Research Notes, 1979, 35(5): 27-28
4 ref., 1 pl.
Subject Codes: 6.1
CAB: 1500081

Growth of Europhium clavigerum and Ceratocystis montia on potato marmite agar was inhibited by oil and extractives obtained from resin-impregnated areas surrounding Dendroctonus ponderosae galleries. Hyphae were able to spread into oil-containing regions of the agar after the mycelium came into contact with the air.

875. SMITH, R.B. Infection and development of dwarf mistletoes on plantation- grown trees in British Columbia.
Info. Report, Pacific NW Res. Centre, Canada, 1974, No. BC-X-97: 21 pp.
10 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 451510

Artificial inoculations were made on 11 species of conifer in a plantation at Victoria with four dwarf mistletoe species native to British Columbia (Arceuthobium douglasii, A. americanum, A. laricis and A. tsugense). An assessment of the degree of compatibility between host and parasite was made by comparing dwarf mistletoe seed retention and germination, infection %s, endophytic growth rates and aerial shoot production on the same host species. Resistance mechanisms were shown to operate at various stages in the life cycle of the parasite, ranging from a reduction of seed germination in some dwarf mistletoes to apparent immunity. A. douglasii was the most host-specific dwarf mistletoe, followed in order by A. americanum, A. laricis and A. tsugense; the last-named

was able to infect species of six coniferous genera. The results indicate that there are two physiologically differing populations of A. tsugense, one on Tsuga heterophylla and the other on Pinus contorta var. contorta. In subsidiary tests with A. campylopodum from northern Washington, USA, Pinus ponderosa was successfully inoculated but inoculation of T. heterophylla failed. A study was made from 1963 to 1972 of 56 cankers of white-spored C. coleosporioides on Pinus contorta var. latifolia in Alberta. Some new cankers were formed during this period. Of the 23 cankers originally studied in 1963, six were still sporulating in 1972, and two of these had sporulated in each year. By 1972, 60% of the cankers were dead.

876. SMITH, R.B., WASS, E.F. Field evaluation of ecological differentiation of dwarf mistletoe on shore pine and western hemlock.
Canadian Journal of Forest Research, 1976, 6(2): 225-228
10 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 878446

Rates of infection of Pinus contorta and Tsuga heterophylla by Arceuthobium tsugense were studied on Vancouver Is., British Columbia in stands of varied composition in which either predominantly T. heterophylla or P. contorta or both species were infected. Each species was more susceptible to A. tsugense already parasitizing a tree of the same species; these results conform with those from controlled, cross-inoculated studies. The existence of 2 populations of A. tsugense is postulated.

877. SMITH, R.B., WASS, E.F. Infection trials with three dwarf mistletoe species within and beyond their known ranges in British Columbia.
Canadian Journal of Plant Pathology, 1979, 1(1): 47-57
16 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1147037

Seeds of (a) Arceuthobium tsugense, (b) A. douglasii, and (c) A. americanum were collected in late summer and early autumn in 1970, 1971 and 1972 and stored at 1 deg. C until used for inoculation. Pinus contorta (2 varieties), Tsuga heterophylla and Pseudotsuga menziesii were inoculated in Victoria Watershed (coastal; natural range of (a)), 130 - Mile Lake (cold interior; natural range of (c)), Oyama (dry interior, natural range (B) and (C)) and Wilson Creek (humid interior; natural range of (c)). Seed collection sites, inoculation sites and natural distribution of the mistletoes are shown on a map. Successful infections were obtained with (a) and (c) but not (b) outside their known ranges; the restricted distributions of (a) and (c) are attributed to historical factors.

878. STALEY, J.M. Lophodermella cerina, a pathogen of pine foliage.
Phytopathology, 1979, 69(9): 1045-1046
Subject Codes: N/A
CAB: 1175939

The distribution and hosts of L. cerina are described. Inoculation of Pinus ponderosa with naturally produced inoculum under field conditions produced significant disease development. Natural spore germination is by appressorial formation, with penetration through the cuticle. The normal disease cycle is one year but artificial inoculation with a low density of ascospores resulted in a 2-year cycle.

879. STEPHAN, B.R., BUTIN, H. The development of canker-like disease in Pinus contorta provenances.
European Journal of Forest Pathology, 1980, 10(7): 410-419
22 ref.
Language: de
Summary Languages: en, fr
Subject Codes: 1.4, 7.3
CAB: 1319245

P. contorta sspp. contorta, latifolia and murrayana, raised from seed collected at nine different sites in western North America, were inoculated with Crumenulopsis sororia and Lachnelluia rehmii. The canker damage, principally provoked by C. sororia, varied among stands of different provenance. Among plants of P. contorta ssp. contorta, all of coastal provenance, 85% showed no damage. The most susceptible plants belonged to P. contorta ssp. murrayana. On average, 40% of plants of this subspecies, collected from four sites, escaped damage. Almost all the representatives of P. contorta ssp. murrayana collected from two mountain provenances in California had more than two cankers per tree.

880. STROBEL, G.A., SUGAWARA, F. 1986. The pathogenicity of ceratocystis montia to lodgepole pine pinus contorta. Canadian Journal of Botany. 64(1):113-116.

Ceratocystis montia (rumb.) Hunt, an ascomycetous fungus, is associated with bark beetle infested lodgepole pine in the intermountain region of USA and portions of western Canada. The organism, when inoculated into lodgepole pine (20 years old) caused necrosis of the inner bark, a blue-stained appearance of the sapwood, and chlorosis and necrosis of the foliage. Loch's postulates were fulfilled in these experiments. Particles of inner bark provided the best support for fungal growth and inhibitors of fungal growth may develop in sapwood during the process of drying.

881. SUTHERLAND, J.R., et al. Sirococcus blight not seed-borne on serotinous lodgepole pine.
Can. For. Service, July-Sept. 1982, Research Notes, 2(3): 20-21
Subject Codes:
RCA: X1123

882. SUZUKI, K., MALLETT, K.I., HIRATSUKA, Y. 1985. Changes in water potential components in lodgepole pine seedlings inoculated with armillaria mellea. Phytopathology. 75(11):1339.

883. TAINTER, F.H. Development of Cronartium comandrae in Comandra umbelata.
Canadian Journal of Botany, 1973, 51(7): 1369-1372
11 ref. + 2 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 217894

Describes and illustrates the development of Cronartium comandrae (the cause of a locally serious disease of 2- and 3-needled pines, e.g. Pinus contorta and P. ponderosa, in the USA on its alternate (herbaceous) host, Comandra umbellata.

884. TAUER, C.G. Sweetfern rust resistance in jack pine seedlings: geographic variation.
Canadian Journal of Forest Research, 1978, 8(4): 416-423
26 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1071800

Inoculation of Pinus banksiana seedlings from 47 provenance collections with basidiospores of Cronartium comptoniae from Cloquet, Minnesota, demonstrated the existence of a band of relatively high resistance extending from SW Quebec, through SE and N. Lower Michigan, into NE Wisconsin. Provenances at increasing distance from this band possess decreasing resistance. A distribution map of the rust together with the two alternative hosts, sweet gale (Myrica gale) and sweet fern (Comptonia peregrina) is given. No resistance was found in lodgepole pine (P. contorta var latifolia) from 3 sources.

885. THIES, W.G. Frequency of pine stump colonization by Fomes-annosus on the Fremont National Forest, Oregon, USA.
Plant Dis. Rep., 1979, 63(7): 542-545
Subject Codes: N/A
BIO: 69019169

Thirty pine (Pinus ponderosa, P. contorta) stands were surveyed to estimate the distribution and percentage of stumps colonized by F. annosus. Of 1001 stumps assayed, only 22 (2.2%) from 12 widely separated stands were colonized by the pathogen.

886. TSUNEDA, A., HIRATSUKA, Y. Scopinella gallicola, a new species from rust galls of Endocronartium harknessii on Pinus contorta.
Can. J. Bot., 1981, 59(7): 1192-1195
Language: en
Summary Languages: fr
Subject Codes: N/A
LISC: 620015

A new species of Scopinella is described and illustrated. This species, Scopinella gallicola, occurs on Pinus contorta galls caused by Endocronartium harknessii. It differs from previously described species mainly in its unusual habitat, size and shape of the ascocarp, and two and four-spored asci. The Harziella anamorph is also described. No anamorph has been reported in other species.

887. TSUNEDA, A., HIRATSUKA, Y., MARUYAMA, P.J. Hyperparasitism of Scytalidium uredinicola on western gall rust, Endocronartium harknessii.
Canadian Journal of Botany, 1980, 58(1): 1154-1159
9 ref., 9 fig.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1301578

This hyperparasite reduces the inoculum potential of western gall rust on pine (Pinus banksiana and P. contorta) by disintegrating spores and the basal cell region of the active rust sori. It forms abundant arthroconidia among the rust spores, thus imparting a yellowish green to whitish grey appearance to infected sori. Hyphae penetrate the wood tissue of the galls and destroy rust hyphae to a depth of 300 mu m below the sori. On water agar S. uredinicola disintegrates rust spores within 48-72 h without penetration. Its use for the biological control of pine stem rusts is considered.

888. VAN SICKLE, G.A. Chemotherapy trials on sweetfern blister rust cankers.
Bi-monthly Research Notes, 1973, 29(3): 20
1 ref.
Subject Codes: N/A
CAB: 235028

Cronartium comptoniae is the principal fungus attacking hard pines in the Maritime Provinces of Canada. Experiments were made to control sporulation by injecting heavily infected Pinus contorta with various substances (dimethyl sulphoxide, cryptosporiopsin, fuel oil, and fuel oil + phytoactin). Treatments reduced sporulation slightly but not significantly. It is suggested that treatment might be more effective on younger trees in an earlier stage of infection.

889. VAN SICKLE, G.A., SMITH, R.B. Dwarf mistletoe controls in British Columbia.
Gen. Tech. Rep., Pacific SW For. & Range Experiment Stn., 1978, No. PSW-31: 106-112
12 ref.
Subject Codes: N/A
CAB: 1299414

The distribution and importance are briefly reviewed for the 4 species of Arceuthobium which affect mainly western hemlock, lodgepole pine, Douglas-fir and western larch. Control measures applied or tested in recent years are described and discussed, including aerial and ground surveys, thinning, removal of residual trees after felling, treatment of advance growth, fringe planting (of resistance species around the edge of a stand), scarification, and sanitation felling. From authors' summary

890. VAN SICKLE, G.A., WEGWITZ, E. Silvicultural control of dwarf mistletoe in young

lodgepole pine stands in Alberta and British Columbia.
Report, Pacific Forest Research Centre, Canada, 1978, No. BC-X-180: 11 pp.
7 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1442734

Treatment for Arceuthobium americanum involved felling or pruning infected trees. Ten years after start of treatment, average percentage changes in infected trees were as follows: on untreated plots, +23%; under thinning and pruning, -5%; when complete eradication was attempted, -34%. Mistletoe was not eradicated from any stand; mortality of affected trees increased with age of stand (varying from 22 to 37 years).

891. VON WEISSENBERG, K. Pathogens observed on lodgepole pine grown in Finland.
European Journal of Forest Pathology, 1975, 5(5): 309-317
9 ref.
Language: en
Summary Languages: de, fr
Subject Codes: N/A
CAB: 564674

Briefly reviews the literature on pathogens observed on Pinus contorta var. latifolia in plantations and on trial plots (shown on a map), and gives the results of a questionnaire survey of forest organizations in Finland on mortality and damage in this species. Heterobasidion annosum (Fomes annosus) and Scleroderris lagerbergii caused the most serious damage; Lachnellula subtilissima (Trichoscyphella calycina), Crumenulopsis (Crumenula) sororia and Scelerophoma pityophila caused damage less frequently. The majority of 300 stands have reached an age of 40-60 years and their health is described as satisfactory to good.

892. WAGN, O. Infection experiments with Fomes annosus in shelter trees.
Tidsskrift for Planteavl, 1971, 75(6): 766-773
Language: da
Summary Languages: en
Subject Codes: N/A
CAB: 122250

Saplings of 74 different tree species were planted on old arable land (in Denmark) in 1962 together with infected posts (one to every sixth plant) as sources of inoculum. After 5 years, trees began to die, and individuals of 41 species were dead at the end of 1970. F. annosus was found in the roots of some but not all species, and it is concluded that Pinus contorta, alder, Cotoneaster bullatus, Crataegus oxyacantha, Sorbus aucuparia, S. intermedia and Rosa spp. should not be planted in threatened areas. The list of trees killed includes 15 hitherto unrecorded hosts of F. annosus.

893. WAGN, O. Fomes annosus (Heterobasidion annosum) is feared by foresters: susceptibility of tree species to attack.
Hedeselskabets Tidsskrift, 1978, 99(5): 100-102
Language: da
Summary Languages:
Subject Codes: 2.3
CAB: 962078

A report on a 15-year-old "infection trial" established at Studsgard Research Station, Denmark, with some 70 shelterbelt species. Mortality in Pinus contorta, the most susceptible species, was 80% vs 25% in P. nigra (and also in Picea sitchensis); it was about 20% in Larix leptolepis, but no L. X eurolepis had died. The most susceptible hardwoods (over 50% mortality) were Sorbus aucuparia and wild pear (Pyrus communis). Ulmus pumila was more susceptible than other elms. Species which so far showed no symptoms included small-leaved linden (Tilia cordata) and hybrid aspen (Populus tremula X P. tremuloides).

894. WALLIS, G.W. Growth characteristics of Phellinus (Poria) weirii in soil and on root and other surfaces.
Canadian Journal of Forest Research, 1976, 6(2): 229-232

4 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 878419

A series of experiments was made: (a) alder wood inoculated with Phellinus (Inonotus) weirii was placed 2, 5 and 10 cm from uninfected Pseudotsuga mensiesii roots 15-309 cm below the soil surface in a plantation; (b) mycelial growth was studied on glass rods and Tsuga heterophylla heartwood strips and root pieces in glass tubes containing sieved mineral soil; (c) glass rods and pseudotsuga mensiesii heartwood and roof bark strips were used to bridge inoculated wood blocks and uninfected P. menziesii roots in a plantation; and (d) mycelial growth was studied in the field after root inoculations of 6 coniferous tree species. Growth was rapid on P. menziesii and T. heterophylla in all experiments; it was slow along glass (1-2 cm in 16 weeks), through soil (only 40% of roots 2 cm from inoculum were colonized after 18 months) and on Pinus contorta, P. monticola, P. ponderosa and Thuja plicata. Mycelial growth also took place on the roots of minor vegetation and on rock faces in contact with infected roots.

895. WALTERS, J.W. Importance of bole infections in spread of lodgepole pine dwarf mistletoe.
Plant Disease Reporter, 1974, 58(12): 1066-1069
6 ref.
Subject Codes: N/A
CAB: 441359

Gives the results of a survey of 1352 infections of Arceuthobium americanum on 1010 trees of Pinus contorta in Colorado and Wyoming. The relation between tree diameter and vigour of the mistletoe plant (assessed by height and abundance of shoots) was used to determine which bole infections provided a substantial seed source. The removal of all bole-infected trees less than 5 inches in diameter at the bole infection centre would eliminate 97% of the intermediate and high-vigour infections.

896. WHITNEY, R.D., BOHAYCHUK, W.P. Pathogenicity of Polyporus tomentosus and P. tomentosus var. circinatus on seedlings of 11 conifer species.
Canadian Journal of Forest Research, 1976, 6(2): 129-131
Language: en
Summary Languages: fr
Subject Codes: 6.1
CAB: 878413

Freshly-germinated seeds of 11 species were inoculated with each of 5 isolates of P. tomentosus and P. tomentosus var. circinatus. The seedlings were incubated and disease ratings were given after 3, 5, 7 and 9 months. P. tomentosus caused more severe disease symptoms than P. tomentosus var. circinatus. The most susceptible tree species were Pinus ponderosa and Pinus contorta; Picea rubens and Pinus trobus were the least susceptible. The 3 species known to be damaged in natural stands, viz. Picea glauca, Picea mariana and Larix laricina were ranked 3rd, 4th and 5th in susceptibility, respectively.

897. WHITNEY, H.S., FUNK, A. Pezizella-chapmanii new-species - a discomycete associated with bark beetle galleries in western conifers.
Can. J. Bot., 1977, 55(8): 888-891
Subject Codes: 6.1
BIO: 64030790

P. chapmanii sp. nov. (Helotiales) is described from apothecia found in the galleries of various bark beetles in conifers of western Canada - i.e. Dendroctonus rufipennis Kirby galleries in Picea glauca (Moench) Voss; D. ponderosae Hopkins galleries in Pinus contorta var. latifolia Engelmann and in P. ponderosa Laws.; D. murrayanae Hopkins galleries in P. contorta var. latifolia; and D. pseudotsugae Hopkins galleries in Pseudotsuga menziesii (Mirb.) Franco. In agar culture a prominent Malbranchea conidial state is produced.

898. WILFORD, E. The effects and control of lodgepole pine dwarf mistletoe in the

Cariboo forest region. E.P. 910. IN: Forest Research Review 1981-82. Ministry of Forests, Victoria, B.C., 1983: 58
Subject Codes: N/A
RCA: X1067

899. WILLIAMS, W.T. Distribution of 3 species of dwarf mistletoe on their principal pine hosts in the Colorado Rocky Mountain front range.
Phytopathology, 1971, 61(11): 1324-1325
Subject Codes: N/A
BIO: 72016260

900. ZILLER, W.G., FUNK, A. Studies of hypodermataceous needle diseases. III. The association of Sarcotrochila macrospora n.sp. and Hemiphacidium longis porum n.sp. with Pine needle cast caused by Davisomycella ampla and Lophodermella concolor.
Canadian Journal of Botany, 1973, 51(10): 1959-1963
10 ref. + 3 pl.
Subject Codes: N/A
CAB: 371875

Describes two new species of Hemiphacidiaceae on needles of Pinus contorta in British Columbia, and discusses their taxonomic position, characteristics in culture, and apparent roles as natural control agents of pine needle-cast.

901. ZIMMERMAN, G.T., LAVEN, R.D. 1984. Ecological interrelationships of dwarf mistletoe arceuthobium-americanum and fire in lodgepole pine Pinus contorta forests. American Journal of Botany. 71(5):61.

## 6.3 FIRE

902. ALEXANDER, M.E. Estimating fuel weights of 2 common shrubs in Colorado lodgepole pine stands.
U.S. For. Serv. Research Note, RM, (354), 1978: 1-4
Subject Codes: N/A
BIO: 16039486

903. ALEXANDER, M.E. Four fire scar records on lodgepole pine (Pinus contorta Dougl.) in north-central Colorado.
Southwest. Nat., 1980, 25(3): 432-434
Subject Codes: N/A
RCA: X1205

904. ALEXANDER, M.E., YANCIK, R.F. The effect of precommercial thinning on fire potential in a lodgepole pine stand.
Fire Management Notes, 1977, 38(3): 7-9, 20
8 ref., 2 pl.
Subject Codes: 7.7
CAB: 1358254

A quantitative comparison of fuel charateristics before and after thinning for a natural stand of pure, even-aged lodgepole pine in north-central Colorado. The stand had a density of 5250 live stems and 900 dead stems per acre before thinning; the understory consisted of half-shrubs and needle litter covering the ground. Fuel loadings are given by size class (live and dead) and litter type. In almost all categories, fuel weights doubled after thinning. Calculations of potential fire intensity indicated that the rate of head output per acre would be 3X greater after thinning and the rate of fire spread would be increased by 3.5X. Mechanical crushing would reduce this risk by compacting the fuel bed.

905. DIETERICH, J.H. Fire effects in southwestern forests and deserts.
Project RM-2108, Arizona State Univ., Tempe, ARZ, 01 Mar 76 to 01 Feb 87
Subject Codes: N/A
CRIS: 0042986

906. DUBE, D.E. (Compiler). Fire ecology in resource management - workshop proceedings, December 6-7, 1977.
Info. Rep., Northern For. Res. Centre, Canada, 1978, No. NOR-X-210
50 ref.
Subject Codes: N/A
CAB: 1442621

Twenty-seven papers are included, several of which are noted here: Anderson, H.A. Annual burning and vegetation in the aspen parkland of east central Alberta. Alexander, M.E. Reconstructing the fire history of Pukaskwa National Park (Ontario). Quintilio, D. Fire behaviour in natural forest stands. Tande, G.F. Management implications of historic fire periodicity in relation to changing climate (based on forest fire history of the Athabasca River valley around Jasper townsite, Alberta). Dube, D.E. Prescribed fire on Henry House Prairie, Jasper National Park (Alberta). Miller, M. Perspectives for fire management in Alberta provincial parks and wilderness areas. Chrosciewicz, Z. Silvicultural uses of fire in midwestern Canada. Carroll, S. The role of fire in the jack pine-lichen woodlands of the Athabasca Plains Region (Alberta) of Canada. Markham, B.J. Activities of the Alberta Fish and Wildlife Division in the use of fire for habitat management. Richardson, C.J. Brush and regrowth control on pasture on Crown lands in Alberta. Edgecombe, A.H. Spring fuel hazard reduction in northwestern Alberta. Skrenek, J.M. The Cameron-Caribou (Alberta) fire control plan. Kourtz, P.H. An application of LANDSAT digital technology to forest fire fuel type mapping. Muraro, S.J. The use of prescribed fire in the management of lodgepole pine (in British Columbia). Gray, H. Slash zones for forest fire suppression. Eastman, D. Prescribed burning for wildlife habitat management in British Columbia.

907. FOSBERG, M.A. Heat and water transport properties in conifer duff and humus. Research Paper, Rocky Mountain For. & Range Experiment Stn., USDA Forest Service, 1977, No. RM-195: 10 pp.
27 ref.
Subject Codes: 8.8.3
CAB: 1431695

The permeability and bulk density of duff and humus layers in soils under ponderosa pine, lodgepole pine and Douglas-fir in Colorado were measured in order to estimate the hydraulic conductivity of these materials. The prediction equation yielded a 50% uncertainty. A model for the diffusion of heat and vapour through ponderosa pine duff was also derived and calibrated. The conductivity and diffusion models are required to provide data for models of forest soil water balance and energy, with particular reference to fire danger studies and fire management.

908. GARA, R.I., LITTKE, W.R., AGEE, J.K., GEISZLER, D.R., STUART, J.D., DRIVER, C.H. 1985. Influence of fires, fungi and mountain pine beetles on development of a lodgepole pine forest in south-central Oregon. 1985. Pages 153-162 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Virtually pure lodgepole pine stands form an edaphic climax community over large areas of the infertile "pumice plateau" of south-central Oregon. During our ongoing studies on the dynamics of these forests we developed the scenario that periodic fires create fungal infection courts in damaged roots; in time, advanced decay develops in the butts and stems of these trees. The mountain pine beetle preferentially selects and kills these trees during the flight season. As these outbreaks develop, additional uninfected trees are attacked. In time, the stage is set for subsequent fires as needles drop, snags fall, and logs decay.

909. GRIGEL, J.E. Air drop tests with Fire-Trol 100 and Phos-Check 205 fire retardants.
Info. Report, Northern For. Res. Centre, Canada, 1971, No. NOR-X-8: 41 pp.
7 ref.
Subject Codes: N/A
CAB: 052038

The two retardants were dropped by a Thrush Commander air-tanker on three sites: (1) an open field; (2) a Lodgepole Pine stand; (3) a White Spruce/Aspen stand. There was little difference between the distribution patterns of the two retardants on the same site, but the patterns differed between sites. The amount of retardant reaching the ground was highest for (1) and that retained in the canopy for (2); on (2), 66% of the Fire-Trol and 67% of the Phos-Check was retained in the canopy. The results (given in tables, graphs and diagrams) suggest that the Thrush Commander has limited value in establishing fire lines. 1923 Pre-emergence treatments with (a) Tok E 25, (b) chloramben, and (c) diphenamid gave promising results. Pinus radiata and Pseudotsuga menziesii seedlings tolerated up to 10 lb. a.i./acre of (a) and (b); rates of 4-5 lb. a.i./acre gave excellent control of broadleaved weeds and annual grasses. P. menziesii tolerated 13 lb. a.i./acre of (c), which gave satisfactory weed control at 7-8 lb. Only (a) was suitable for Pinus contorta. When triazine weed killers had failed to give protection in the second year owing to slight surface soil erosion, spraying with 2 lb. a.i. atrazine + 2 gal. summer oil in 40-60 gal. water/acre eliminated weeds up to 5" high.

910. HAWKES, B.C., LAWSON, B.D. Fire hazard appraisal in precommercially thinned stands of British Columbia coastal Douglas-fir and interior lodgepole pine.
IN: Proc. of the Sixth Meteorology Conference, Seattle Washington, April 22-24, 1980: 137-145
Subject Codes: 7.6.2
RCA: X1139

911. KOEHLER, G.M., HORNOCKER, M.G. Fire effects on marten (Martes americana) habitat in the Selway-Bitterroot Wilderness.
Journal of Wildlife Management, 1977, 41(3): 500-505
31 ref.

Subject Codes: 3.6
CAB: 1369146

In an area of 21 km2 where fires have produced a mosaic of forest communities, including subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii) and lodgepole pine, results from 255 track observations, 80 captures of 13 live-trapped martens, and scat analyses, over a 13-month period in 1973-1974, suggest that the mosaic of forest types created by wildfires improves the diversity and abundance of food during the summer, whilst mature forests of spruce and fir, with more than 30% canopy cover, provide shelter and food in winter.

912. LAWSON, B.D. Fire behavior in lodgepole pine stands related to the Canadian Fire Weather Index.
Info. Report, Pacific For. Res. Centre, Canada, 1973, No. BC-X-76: 26 pp. 9 ref.
Subject Codes: N/A
CAB: 203409

Test fires were made on 28 plots in Pinus contorta stands on two dry sites and one fresh site N. of Prince George, British Columbia, in 1968-70. The logarithm of the rate of spread increased linearly with increasing Fire Weather Index; the relation was not greatly influenced by the predominant type of litter (Cladonia, moss, or needles). Heading flame length increased linearly with heading flame depth and with the logarithm of the rate of spread. Wind velocities were insufficient to sustain crown fires. The initial behaviour of centrally-ignited and strip-ignited fires is compared. Guidelines are presented for initial control measures within three hazard classes based on the Fire Weather Index.

913. LOTAN, J.E., BROWN, J.K., NEUENSCHWANDER, L.F. 1985. Role of fire in lodgepole pine forests. Pages 133-152 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Fire is one of the most important factors involved in the establishment and development of many lodgepole pine forests in North America. In the Rocky Mountains lodgepole pine is usually considered a fire-maintained seral type. But even here fires vary greatly in frequency, intensity, size, and other characteristics. A particular rife regime greatly affects forest succession, longevity of the species, stocking, and species composition; and fire also influences the incidence of insects and diseases. Fuel quantity changes over time and with it fire behavior potentials in natural and slash fuels. Fire behavior potentials are greatest when buildup of dead fuel coincides with development of understory conifers. Most fires are low intensity, creeping, surface fires, but high intensity crown fires during severe weather burn the most acreage. Fires, stand development, mortality influences, and fuel accumulation interact in a complex network. Sound management of lodgepole pine requires that we understand the comlexities of lodgepole pine ecology, including the role of fire, and manage fire within that context.

914. PERRY, D.A. Fire history as related to vegetative types on eastern slopes of the Oregon Cascade Mountains.
Project ORE-FS-145-S, Oregon State Univ., Corvallis, ORE, 01 Oct 80 to 30 Sep 82
Subject Codes: 3.6
CRIS: 0083594

Objectives: Establish the fire frequency (one or more indices) for the east slopes of the Cascade Mountains of Oregon. Evaluate fire frequency in terms of site, plant community and/or habitat. Establish, if possible, isopyrotic lines of fire occurrence in the area. Approach: The frequency with which fire occurred in vegetative types can be important in developing fire management guidelines. Limited data are presently available for this area. The study would combine information from the limited data available with new data to be collected in the study to provide fire frequency guides by vegetative and site classes and provide a map of "isopyro" lines of equal fire frequencies. Fire frequencies would be determined from fire scarred trees and vegetative types according to standard habitat type/plant community guides. Progress: Ponderosa pine stands on the Pringle Falls Experimental Forest were sampled. Trees were felled and a master chronology of tree ring widths begun.

915. SCHMIDT, W.C. Forests of the Rocky Mountain west. IN: Effects of Fire on Flora - A State of Knowledge Review.

USDA FOR. Serv. Gen. Technical Report WO-16: 11-16
Subject Codes: N/A
RCA: X1206

916. WARD, F.R., SANDBERG, D.V. Predictions of fire behavior and resistance to control for use with photo series for the ponderosa pine type, ponderosa pine and associated species type, and lodgepole pine type.
Gen. Tech. Rep., Pacific Northwest For. and Range Experiment Stn, USDA, PNW-115: i + 46 pp.
4 ref.
Subject Codes: N/A
CAB: 1539656

917. ZIMMERMAN, G.T., LAVEN, R.D. 1984. Ecological interrelationships of dwarf mistletoe arceuthobium-americanum and fire in lodgepole pine Pinus contorta forests. American Journal of Botany. 71(5):61.

## 6.4 CLIMATE

918. BANNAN, M.W., BINDRA, M. The influence of wind on ring width and cell length in conifer stems.
Can. J. Bot., 1970, 48(2): 255-259
Subject Codes: N/A
BIO: 51068907

919. BERGEN, J.D. Wind speed distribution in and near an isolated narrow forest clearing.
Agric. Meteorol., 1976, 17(2): 111-133
Subject Codes: N/A
BIO: 63043871

Windspeeds were measured on a 3-dimensional array in and near a 10 m by 50 m clearing cut in a 10 m high lodgepole pine stand. Measurements made while the wind direction above the canopy was perpendicular to the long axis of the clearing are used in a continuity calculation to establish the velocity field for the flow in and downward of the clearing. The ratio of the local speed to the estimated above-canopy friction velocity is approximately independent both of the latter and of the above-canopy stability. Minimum speeds occur at the clearing center and at the midcrown region on the lee edge of the clearing. Speed maxima occur at sub-canopy levels on either edge and above the lee edge. Clearing effects behind the clearing to at least 25 m, but are only slightly apparent upwind of the clearing. The continuity calculation indicates a separation of the flow beginning at the mid-clearing floor and extending to the upper surface of the lee canopy. Reattachment occurs 4 or 5 m behind the lee clearing edge, with strong reverse flow apparent upwind from that point. An approximate analysis of the flow is made in terms of a penetrating inviscid jet model presented by previous authors, and an adaptation of a solution for an inviscid jet impinging on a screen. Agreement with the observed flow pattern is fair.

920. BERGEN, J.D. The independence of the point-to-point variations in windspeed and temperature in a lodgepole pine stand.
USDA For. Serv. Research Note, Rocky Mountain For. and Range Exp. Stn., 1974, No. RM-258: 2 pp.
4 ref.
Subject Codes: 3.1
CAB: 363212

Local variations in wind speed and air temperature at particular heights within the stand appear to be independent and argue against persistent effects of local thermal convection.

921. BERGEN, J.D. Variations of air temperature and canopy closure in a lodgepole pine stand.
USDA For. Serv. Research Note, Rocky Mountain For. and Range Exp. Stn., 1974, No. RM-253: 3 pp.
5 ref.
Subject Codes: 3.1
CAB: 363211

Air-temperature measurements at heights between 1 and 8.6 m within the stand were scaled by the temperature gradient above the canopy, measured at heights between 11.5 and 22.5 m. The point-to-point variation of the scaled temperatures in relation to the mean for all locations showed no significant correlation with the local canopy cover at the same points.

922. BERGEN, J.D. Variation of windspeed with canopy cover within a lodgepole pine stand.
USDA For. Serv. Research Note, Rocky Mountain For. and Range Exp. Stn., 1974, No. RM-252: 4 pp.
4 ref.
Subject Codes: 3.1
CAB: 363210

Presents further results of a study of wind speed at six heights (1.07 - 8.50 mJ) extending to the top of a 70-year-old stand of Pinus contorta var. latifolia in Wyoming. For each height, there was no correlation between the wind speed and the local canopy cover (assessed by determining the fraction of the field of view seen from below that was unobstructed by foliage).

923. BERGEN, J.D. Vertical air temperature profiles in a pine stand: spatial variation and scaling problems.
Forest Science, 1974, 20(1): 64-73
9 ref.
Subject Codes: 3.1
CAB: 304819

Describes results from air-temperature measurements taken simultaneously with wind- speed measurements in a 70-year-old Pinus contorta stand in Wyoming. Horizontal variations are discussed and a composite temperature profile is derived, characteristic of the stand near noon on clear days, in which local maximum temperatures are indicated at the height of maximum foliage concentration.

924. BERNDT, H.W., FOWLER, W.B. Rime and hoar frost in upper slope forests of eastern Washington, USA - lodgepole pine.
J. Forest, 1969, 67(2): 92-95
Subject Codes: N/A
BIO: 50128534

925. COCHRAN, P.H., BERNTSEN, C.M. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures.
Forest Science, 1973, 19(4): 272-280
12 ref.
Subject Codes: N/A
CAB: 257316

Gives results of a series of experiments to test the hypothesis that seedlings of Pinus contorta are more tolerant than those of P. ponderosa to low night temperatures. When exposed to a minimum temperature less than 23 deg F, mortality of seedlings less than 36 days old was greater in P. ponderosa but differences in relative tolerance between the species had disappeared at 2 months. A second exposure to low temperature increased mortality. When exposed to a minimum temperature of 18 deg, 36-day-old seedlings were more susceptible than 22-day-old seedlings. Seedlings previously exposed to a temperature of 34 deg survived better at temperatures 20 deg than seedlings that had not been pre-conditioned. Seedlings of both species that had germinated in late spring and had been raised

until the autumn in the greenhouse, or in planting beds, were tolerant to temperatures of 15 deg. These results are discussed in relation to distribution of the two species in Oregon.

926. DOBBS, R.C., MCMINN, R.G. Hail damage to a new white spruce and lodgepole pine plantation in central British Columbia.
Forestry Chronicle, 1973, 49(4): 174-175
9 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 226568

Analyzes the influence of species, age (2-4 years old from seed) and height, and ground cover on the incidence and type of damage caused by a 10-min storm in July 1972, with hailstones 1-11/2 inches in diameter driven by SW winds, in research plots planted in 1970-72. Only 14% of the trees escaped damage and 2% were killed by hail. In general, damage was more severe in Pinus contorta var. latifolia than in Picea glauca, and in older trees of either species. Competing vegetation provided some degree of protection against stem lesions and defoliation but not against damage to leaders or terminal buds.

927. DORMLING, I., ERIKSSON, G., JONSSON, A. Photo- and thermoperiodism in Pinus sylvestris and P. contorta.
Rapporter och Uppsatser, Institutionen for Skogsgenetik, 1977, No. 27: 48-57
4 ref.
Language: sv
Summary Languages: en
Subject Codes: N/A
CAB: 1358342

A continuation of studies at the Swedish Agricultural University, Stockholm, on development of frost hardiness in various provenances of Scots pine and lodgepole pine.

928. FOX, D.G. Forest and mountain meteorology.
Project RM-2151, Rocky Mountain For. & Range Exp. Sta., Fort Collins, COL, 29 Jul 76 to 01 Aug 81
Subject Codes: N/A
CRIS: 0043349

Objectives: Develop methodologies that will permit simulation of relationships between meteorological processes and forest and rangeland management and the incorporation of all pertinent meteorological information into land use planning processes. Approach: Develop capabilities for determining three-dimensional wind field over forested mountainous terrain; derive for field application detailed quantitative descriptions of interactions between atmosphere, plants, and soils; develop methods for analyzing meteorological data so as to provide meaningful information for application over mountainous terrain. Progress: The variable lid box model developed earlier was refined by using modeled input data on mixing depth in mountain valleys. Research on moisture content of live vegetation has been nearly completed with a series of publications presenting a validated model for water relations of Pinus contorta. Work is continuing on simulating the forest meteorological environment. Remote automatic weather stations have been installed on a round, isolated mountain near San Antonio in northern New Mexico. The data will be used to validate surface temperature and wind models. The study has been transferred to RWU-RW-2110. Air resources research has led to a refinement of the role Federal Land Managers play in visibility and other air quality concerns. Data on visibility and particulate measurements in Craig, Colorado have been collected and are in the process of being analyzed.

929. GALLAGHER, G.J. Windthrow in State forests in the Republic of Ireland.
Irish Forestry, 1974, 31(2): 154-167
19 ref.
Subject Codes: N/A
CAB: 471902

Outlines the history of windthrow in the State forests since 1916 and describes the storm weather conditions that have occurred in the Irish Republic at times of

windthrow. Severe gales are likely to cause some damage each year. Soil and site conditions predispose 10% of the plantations to damage, but windthrow is greatest at the centre of a storm irrespective of site. Picea sitchensis and Pinus contorta are the major species thrown, and young plantations on ploughed ground are thrown more frequently.

930. GARY, H.L. Airflow patterns and snow accumulation in a forest clearing.
Coronado, California, USA, 1975: 106-113
16 ref., 1 pl.
Subject Codes: N/A
CAB: 892419

A study is reported of the airflow patterns in relation to the accumulation of snow in a clearing and the the surrounding 80-yr-old Pinus contorta stand in Wyoming. In general, the snow accumulation was related to the average duration and direction of airflow with max. and min. accumulation at the upwind and downwind edges resp. of a well- developed back-eddy centred on the downwind border of the clearing.

931. GLOYNE, R.W. Shelter in agriculture, forestry and horticulture - a review of some recent work and trends.
ADAS Quarterly Review, 1976, No. 21: 197-207
30 ref.
Subject Codes: N/A
CAB: 782900

In a short section on forestry, mention is made of the two main classes of wind problem viz. wind-damage and wind-throw; and the effects of wind on the establishment of young trees. Attempts to map the relative vulnerability of an area of land to gale damage have proved difficult. Some indications are given of vulnerability in relation to topography. Brief details are given of an experiment in SW Scotland concerning the effects of a shelter fence on growth of Pinus contorta seedlings.

932. HAGNER, M. Frost-rings in provenances of Pinus sylvestris grown in Canada. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 231-246
13 ref.
Subject Codes: N/A
RCA: X1088

933. JONSSON, A., ERIKSSON, G., DORMLING, I. A summary of studies of frost hardiness of Pinus contorta seedlings grown in climatic chambers. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note. No. 30, 1981: 75-81
3 ref.
Subject Codes: N/A
RCA: X1078

The main purposes of the investigation were: to determine the photo- and thermo-period requirements of different populations to reach frost hardiness and to examine as many characters as possible to find those that have high correlation with hardiness and are feasible for early tests.

934. JONSSON, A., ERIKSSON, G., DORMLING, I., IFVER, J. Studies on frost hardiness of Pinus contorta Dougl. seedlings grown in climate chambers.
Studia Forestalia Suecica, 1981, No. 157: 47 pp.
66 ref.
Language: en
Summary Languages: sv
Subject Codes: N/A
CAB: 1418888

Methods of testing for tolerance of frost in controlled environments are described. A range of photoperiods with varying temperature regimes reaching - 10 deg. C were used. Results from such tests corresponded well with observed frost

resistance under field conditions among populations originating from latitudes between 47 deg. and 63 deg. N. Frost hardiness was positively related to the length of the night period, though trees from northern provenances attained hardiness in shorter nights than those from more southerly provenances. Hardening was promoted by low night temperatures. Frost resistance was negatively correlated with the extension growth of secondary needles and was positively correlated with the percentage of dry matter in the apical 3 cm of shoots and with intensity of anthocyanin pigmentation.

935. KEDROWSKI, R.A. Changes in cold hardiness of introduced and native interior Alaskan evergreens in relation to water and lipid content during spring dehardening.
Physiol. Plant, 1980, 48(3): 438-442
Subject Codes: 2.7
LISC: 491229

Needle hardiness of introduced yellow pine, Pinus banksiana, lodgepole pine, P. contorta and native white spruce, Picea glauca, were assessed by the effective prefreezing temperature method. Yellow pine needles were less hardy than lodgepole pine or white spruce needles in Alaska on each date measured. Although hardiness decreased in springtime in all species, decreases in hardiness in yellow pine began before temperatures were greater than 20 deg. C, apparently in response to day length, while decreases in hardiness in lodgepole pine and white spruce began only when mean temperatures were greater than 0 deg. C. Hardiness was increased by decreasing the water content of yellow pine and spruce needles. However, only the latter increased its field hardiness by decreased water contents, and only to a small degree. Large decreases in phospholipid occurred during the dehardening period, indicating the presence of major membrane-associated changes. However, changes in hardiness did not closely parallel those in phospholipid; hardiness decreased before phospholipid did in spruce and after phospholipid did in lodgepole pine. In yellow pine, changes in hardiness were more closely related to changes in phospholipid content. Decreases in phospholipid appeared to be correlated with the day length in all species.

936. KIMES, D.S., SMITH, J.A. Simulation of solar radiation absorption in vegetation canopies.
Applied Optics, 1980, 19(16): 2801-2811
26 ref., 12 fig., 4 tab.
Subject Codes: N/A
CAB: 1308473

A solar radiation canopy absorption model, including multiple scattering effects, was developed and tested for a lodgepole pine canopy. Reflectance above the canopy, spectral transmittance to the ground layer, and geometric and spectral measurements of canopy elements were made. Relatively large differentials occurred in spectral absorption by canopy layers, especially in the photosynthetically active region, as a function of solar zenith angle. In addition, the proportion of total gloval irradiance absorbed by individual layers varied greatly as a function of solar zenith angle. However, absorption by the entire canopy system remained relatively constant.

937. KOSSUTH, S.V., BIGGS, R.H. Seedlings response to UV-B radiation of coniferous species.
HortScience, 1979, 14(3): 428
Subject Codes: 5.6
CAB: 1094759

Seven species were grown from seed under UV (280-320 nm) radiation for 11 weeks. Biomass was unaffected in Douglas-fir, and increased in white fir (Abies concolor). Dry wt. biomass of other species (Pinus taeda, P. contorta, P. ponderosa, P. elliottii, and A. procera) was reduced by 5-25%, mostly in the roots. All species except P. taeda had increased leaf densities at higher UV-B irradiances.

938. KOSSUTH, S.V., BIGGS, R.H. Ultraviolet-B radiation effects on early seedling growth of Pinaceae species.
Canadian Journal of Forest Research, 1981, 11(2): 243-248

25 ref.
Language: en
Summary Languages: fr
Subject Codes: 3.0, 5.6, 7.3
CAB: 1395317

Seven coniferous species were grown in a phytotron under 5 UV B radiation regimes for 11 weeks. The irradiation regimes were 765, 680, 637, 310 and 28 mW/m2 as summed over the UV B waveband. The UV B radiation source was FS40 Westinghouse sunlamps filtered with cellulose acetate for 4 treatment irradiation levels and clear Mylar for the control. Biomass production of lodgepole pine, loblolly pine, noble fir (Abies procera), ponderosa pine and slash pine was significantly reduced at the highest UV B radiation level and somewhat less at the lower levels. These species were rated as slightly susceptible (5-25% reduction in biomass). Biomass production of Douglas-fir was unaffected and white fir (Abies concolor) biomass was increased significantly by UV B radiation at 310, 637 and 680 mW/m2 UV B radiation intensities. Root weight tended to be reduced more than shoot weight, thereby decreasing root/shoot ratios significantly in certain UV B regimes. Leaf area declined significantly with increasing UV B radiation for all species except white fir and Douglas-fir. At the higher UV B irradiance intensities, height was significantly reduced when compared with the Mylar control on loblolly, lodgepole, ponderosa and slash pines and noble fir respectively. Height of Douglas-fir was not altered and that of white fir was increasing significantly at the lowest intensity of UV B radiation tested. From authors' summary.

939. LINES, R. Stability of Pinus contorta in relation to wind and snow. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 209-219
21 ref.
Subject Codes: N/A
RCA: X1029

Studies on the stability of lodgepole pine have continued for 27 years. These include investigation of root/shoot ratios from trees 1-44 years old and root excavations to assess root form and distribution. Wind tunnel studies of crown drag and analyses of crown morphology have been carried out. Results of stability assessments in provenance and progeny trials are presented. Effects of site factors and cultural treatments also influence stability.

940. LINES, R., BOOTH, T.C. Investigation of basal sweep of lodgepole pine and shore pine in Great Britain.
Forestry (OXF), 1972, 45(1): 59-66
Subject Codes: N/A
BIO: 56031322

941. MAYHEAD, G.J., GARDINER, J.B.H., DURRANT, D.W. A report on the physical properties of conifers in relation to plantation stability.
Roslin, Midlothian, UK, Forestry Commission Research and Development Division, 1975: 39 pp.
1 pl., 18 fig., 2 tab.
Subject Codes: N/A
CAB: 662636

Reports research by the UK Forestry Commission in 1972-1975 on factors affecting the wind stability of conifers, with Sitka spruce, lodgepole pine and scots pine as test species. Part I of the paper deals with static characteristics of trees, reporting the results of wind-tunnel tests to investigate the drag coefficient and factors affecting it (e.g. prolonged exposure to wind, removal of branches, tree and branch mass), the interrelations of drag, wind speed and branch mass, deflection of the tree from the vertical, and lift forces. Part II deals with dynamic characteristics under the headings: basic vibration characteristics of a tree (plane of vibration, sway period, damping); origin of damping in the artificial 'tree'; field tests on whole trees (effect of soil type, effect of drainage and effect of root fusion; vortex shading from trees; conclusions on whole-tree swaying); field tests on 'debranched' trees (effect of branches on damping, effect of continued swaying on damping, and effect of ploughing on damping and turning moment); and results from thinning experiments. In general, it is concluded that the fundamental problems are the unpredictability of the wind and the largely inexplicable local variation with site. Future research should probably be concerned primarily with the clarification of problems related to

species and treatments, e.g. work on: thinning regimes and rates of spread of windthrow in damaged crops; variations in wind speed as related to land form; vibration characteristics of the soil; and the use of tree-pulling and swaying of stumps to elucidate the effects of species, site cultivation and drainage.

942. MURPHY, J.C. Photoperiod extension for growth acceleration and flower promotion in lodgepole pine. E.P. 771. IN: Forest Research Review 1981-82. Ministry of Forests, Victoria, B.C., 1983: 69-70
Subject Codes: N/A
RCA: X1069

943. REES, D.J., GRACE, J. The effects of shaking on extension growth of Pinus contorta Douglas.
Forestry, 1980, 53(2): 155-166
27 ref.
Subject Codes: 5.0
CAB: 1299257

Young 2-yr-old potted plants were grown outdoors in an open cold frame and the stems shaken continuously with a wooden framework touching each stem; movement back and forth of stems was by about 1 cm at the midpoint. Results were similar to those in the wind experiment, with 20% less shoot extension, 10% less needle extension and an increase in water potential of about 0.1 MPa relative to the control; shaking for 24 min/day had almost the same effect as continuous shaking. The number of pith cells in a vertical file from apex to base of the stem was reduced by 17% by wind and 13% by shaking, and there was a slight reduction in cell length in both treatments. Available published data on the effect of motion on plants is summarized.

944. REES, D.J., GRACE, J. The effects of wind on the extension growth of Pinus-contorta.
Forestry (OXF), 1980, 53(2): 145-154
Subject Codes: 2.5, 2.11, 3.0, 6.4
BIO: 71051368

The effect of wind on the extension growth of young P. contorta was investigated using a controlled environment wind tunnel. Extension rates of leader and lateral shoots were reduced by about 20% by high wind speed. The ratio of the final length of the laterals to that of the leaders (apical control) was unaffected, as was the radial growth of stems. Water potentials were slightly higher in plants subject to high wind. In another experiment, rates of needle extension were reduced 30% by wind. The experiments are discussed in relation to field observations by others and it is argued that wind is a potent ecological factor adversely affecting tree growth.

945. REES, D.J., GRACE, J. The effect of wind and shaking on the water relations of Pinus contorta.
Physiol. Plant, 1981, 51(2): 222-228
Subject Codes: 2.11
LISC: 596057

It is usually suggested that the effects of wind on plant growth and development are caused by water stress. The author examined this suggestion with a series of experiments in a controlled environment wind tunnel. Cuticular conductance of P. contorta subjected to low and high wind-speeds were determined by weighing detached needles on a microbalance. Although the needles collided with each other at the high wind-speed, there was no effect on cuticular conductance, unlike results obtained elsewhere with broader-leaved plants. The transpiration rates and needle conductances of whole plants were unaffected by exposure to wind or a gentle shaking treatment. Wind and shaking had no effect on total, solute, or pressure potentials, or in any of the parameters describing the pressure-volume curves. It is concluded that the effects of these treatments on growth of P. contorta, reported in previous papers, are unlikely to be caused by tissue water stress.

946. ROBAK, H. Winter injuries in seedbeds in the experimental nursery at Stend after

sowings made in 1959-1972.
Stend, Norway; Norsk Institutt for Skogforskning, 1977: 105 pp.
Language: No
Subject Codes: N/A
CAB: 1118636

Frost heaving of 1+1 plants was the only injury of regular occurrence. Species and provenances with small seeds were particularly affected, apparently without relation to plant density. In Picea abies, frost heaving tended to decrease with increasing plant density up to 1200-1500 plants/m2. The only climatic factor clearly related to frost heaving was autumn precipitation, but the number of days in which soil temp. at 10 cm depth fell below zero may also have been relevant. All species suffered transpiration injuries occasionally. P. abies did not show injuries clearly attributable to frost. P. sitchensis and Pinus contorta showed frost injuries even in provenances approved for use in W. Norway. P. ponderosa was unsuitable. Frost and drought injuries were severe in coastal provenances of Pseudotsuga menziesii.

947. ROBAK, H. Damage registered after winter 1971/72 in field experiments with conifers on frozen ground in W. Norway.
Meddelelser fra Norsk Institutt for Skogforskning, 1976, 32(12): 405-455
11 ref.
Language: no
Summary Languages: en
Subject Codes: 3.2
CAB: 939652

In provenance trials with Picea abies, P. sitchensis, P. glauca, P. omorika, P. lutzii, P. engelmannii and Pinus contorta, some damage (browning) and mortality was observed on snowless frozen ground. Trials planted before 1964 were unaffected; in younger trials damage varied from 0 to 100%. Differences between provenances were significant but differences due to age and site were greater. The damage is mainly attributed to drought rather than cold. There is a 12-page English summary.

948. RONCO, F. Influence of high light intensity on survival of planted Engelmann spruce.
Forest Sci., 1970, 16(3): 331-339
Subject Codes: 3.0
BIO: 52001925

949. SORENSEN, F.C., MILES, R.S. Differential frost tolerance of ponderosa and lodgepole pine mega sporangiate strobili.
For. Sci., 1974, 20(4): 377-378
Subject Codes: N/A
BIO: 60004731

950. WARDLE, P. Winter desiccation of conifer needles simulated by artificial freezing.
Arct. Alp. Res., 1981, 13(4): 419-423
Subject Codes: 2.7
LISC: 642825

When first-year shoots of Picea engelmannii cultivated in New Zealand were artificially frozen and then thawed, the needles developed damage patterns which seemed identical to those seen in natural krummholz of the same species in Colorado. In the same experiment, needles from Pinus contorta plants of krummholz form were not more susceptible to freezing damage than needles from vigorous, erect saplings. This raises the possibility that freezing, rather than water stress, may be the primary cause of winter desiccation in inadequately matured krummholz shoots.

951. WHEELER, N.C. Effect of continuous photoperiod on growth and development of lodgepole pine seedlings and grafts.
Canadian Journal of Forest Research, 1979, 9(2): 276-283
16 ref., 2 pl.
Language: en

Summary Languages: fr
Subject Codes: 4.3, 7.3
CAB: 1258861

Wind-pollinated seed and ramets from lodgepole pine plus-tree selections in British Columbia were established and maintained under 24-h photoperiods for 6 months. Subsequently, these trees were outplanted in the nursery and periodically assessed for ht., diam., and dry wt. Seedlings and grafts developed considerably faster than normal nursery-grown controls during the treatment period, and they maintained an accelerated growth rate during the two growing seasons following outplanting. Root growth was particularly enhanced, as evidenced by the sharply reduced shoot/root ratio of treated seedlings relative to controls. Large differences in growth response existed among wind-pollinated families but family X environment (greenhouse vs. nursery) interaction confounded interpretation. Family performances for treated and control seedlings of the same families were not well correlated (r - 0.24) after two growing seasons. The rapid growth and development of seedlings and grafts under continuous photoperiod can benefit tree improvement programmes by ultimately reducing the establishment time of seedling and clonal seed orchards, particularly for slow-growing species such as lodgepole pine. From author's summary.

952. ZALASKY, H. Chimeras, hyperplasia, and hypoplasia in frost burls induced by low temperature.
Canadian Journal of Botany, 1975, 53(17): 1888-1898
18 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 630925

Describes and illustrates the cytology of frost burrs artificially induced in 4-year-old Pinus sylvestris trees in a greenhouse, and the morphology of burrs artificially induced in Pinus contorta var. latifolia, Ulmus pumila and Tilia cordata in a greenhouse and burrs collected from natural stands of P. contorta var. latifolia, Picea glauca, Betula papyrifera and Populus petrowskyana. The observations show that frost burrs are chromosomal and morphological chimeras.

953. ZALASKY, H. Variation in fascicles, primordia and phyllotaxy of lodgepole pine, Pinus contorta Dougl. var. latifolia seedlings after frost damage.
N. For. Res. Centre, Edmonton, Alberta, Canada, Bi-monthly Research Notes, 1978, 34(4): 26-27
1 pl.
Subject Codes: 2.4, 2.6, 2.7
CAB: 1118779

Containerized seedlings grown in a greenhouse were exposed to frost. Detailed observations were recorded of damage to needles, buds and bark, and of the new growth produced in the course of recovery.

954. ZALASKY, H. Lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) shoot abnormalities from frost injury.
Bi-monthly Research Notes, 1980, 36(5): 21-22
4 fig.
Subject Codes: 1.2
CAB: 1325512

## 6.5 ANTHROPOGENIC

955. ABRAHAMSEN, G., BJOR, K., HORNTVEDT, R., TVEITE, B. Effects of acid precipitation on coniferous forests. IN: Proceedings of the Kuopio Meeting on Plant Damages Caused by Air Pollution, Kuopio, Finland, Aug. 16-18, 1976: 160 pp.
Kuopio Naturalist's Society, Kuopio, Finland, 1976: 81-82
Subject Codes: N/A
BIO: 78032236

956. ABRAHAMSEN, G., BJOR, K., TEIGEN, O. Field experiments with simulated acid rain in forest ecosystems. I. Soil and vegetation characteristics, experimental design and equipment.
Fagrapport, Sur Nedboers Virkning pa Skog og Fisk, 1976, No. FR4/76: 15 pp.
Language: en
Summary Languages: no
Subject Codes: 6.4
CAB: 1146784

Experiments were established in young plantations of Norway spruce, lodgepole pine, Scots pine and birch (Betula pendula), and a mature stand of Scots pine at two sites in southern Norway. Simulated "rain" with pH ranging from 6 to 2 (by adding sulphuric acid) was applied by irrigation at rates of 25 or 50 mm/month during the growing season. Effects on tree growth, ground vegetation, and chemical and biological properties of the soil were studied.

957. ABRAHAMSEN, G., HORNTVEDT, R., TVEITE, B. Impacts of acid precipitation on coniferous forest ecosystems.
Fagrapport, Sur Nedboers Virkning pa Skog og Fisk, 1975, No. FR 2: 15 pp.
16 ref.
Language: en
Summary Languages: no
Subject Codes: N/A
CAB: 619256

Summarizes results of studies in S. Norway and of other studies. Application during two growing seasons of simulated 'rain', artificially acidified to pH3, at 50 mm/month to a semipodzolic forest soil recently reforested with Pinus contorta, increased the acidity of the humus and decreased base saturation, mainly as a result of the leaching of Ca and Mg. Decomposition of P. contorta needles and population densities of earthworms were little affected. Greenhouse experiments on soil artifically leached with dilute $H_2SO_4$ indicated that germination and establishment of Norway spruce were adversely affected when soil pH dropped below 4.0-4.2. It is concluded that although effects detected so far are small, acid precipitation may constitute a severe threat in the long term.

958. ANTIPOV, V.G. Resistance of pine species to industrial gases.
Translation, Fisheries and Environment Canada, 1978, No. OOENV TR-1499: 10 pp.
31 ref.
Language: en
Summary Languages:
Subject Codes: N/A
CAB: 903515

959. BAKER, J., HOCKING, D., NYBORG, M. Effect of atmospheric sulfur dioxide on the pH of rain intercepted by forest trees.
Can. For. Serv. North. For. Research Ctr., Info. Rep. NOR-X-72, 1973: 98-102
Subject Codes: N/A
BIO: 74068648

960. BURK, D.A. The wind of death.
Am. For., 1972, 78(4): 12-15
Subject Codes: N/A
BIO: 72090033

961. CARLSON, C.E. Fluoride induced impact in a coniferous forest near the Anaconda Aluminum plant in northwestern Montana, USA.
Fluoride, 1978, 11(4): 211 pp.
Subject Codes: N/A
BIO: 68057700

The effect of fluorides emitted by the plant at Columbia Falls, Montana (USA) on foliar symptoms and radial growth of Pseudotsuga menziesii, Pinus contorta and P.

monticola was investigated. Histological analyses of pollutant-caused tip necrosis of P. ponderosa and P. menziesii fumigated with F-SO2 and ethyl mercaptan showed that tip necrosis caused by gaseous pollutants can be differentiated from tip necrosis caused by winter drying, drought and salt under laboratory conditions. Analyses of total S and F- were made on a small sample of forest vegetation; total S was elevated suggesting that SO2 may be contributing synergistically or additively with F- relative to conifer injury and damage. Analyses of total F- in wildlife forage showed values greater than 35 ppm. the Montana forage standard for F-, indicating a hazard to indigenous wildlife.

962. CARLSON, C.E. The use of infrared aerial photography in determining fluoride damage to forest ecosystems near an aluminum plant in northwestern Montana, USA.
Fluoride, 1978, 12(3): 135-141
Subject Codes: 8.4
LISC: 237290

A Soderberg aluminum plant consisting of 600 pots emitting between 1150-1800 kg fluoride per day in western Montana, USA, has caused serious injury and damage to nearby forest ecosystems. The fluorides have drastically stressed coniferous trees, causing considerable diameter growth loss and mortality. Aerial infrared photography, with a Fairchild KA-2 cm focal length camera and 24 x 24 cm format, at a scale of 1:4 000 with complete stereo coverage, and transect stereo photography at 1:1 200, and with Kodak ektachrome infrared aero type 2443 was most effective in delineation of stressed stands and in computation of mortality. Trees on nearly 75 000 ha were in various stages of decline, and about 30% of the predicted normal growth. Up to 50% mortality of coniferous trees, primarily western white pine (Pinus monticola), Douglas-fir (Pseudotsuga menziesii), and lodgepole pine (Pinus contorta var. latifolia) occurred in stands 2-5 km from the aluminum plant.

963. CARLSON, C.E., BOUSFIELD, W.E., MCGREGOR, M.D. The relationship of an insect infestation on lodgepole pine to fluorides emitted from a nearby aluminum plant in Montana.
Report, Northern Region, State and Private Forestry, USDA For. Service, 1974, No. 74-14: 21 pp.
14 ref.
Subject Codes: 6.1
CAB: 1455652

964. CARLSON, C.E., DEWEY, J.E. Environmental pollution by fluorides in Flathead National Forest and Glacier National Park.
Missoula, Montana, USDA For. Serv., Div. of State and Private Forestry, For. Insect Branch, 1971: 57 pp.
28 ref., 7 pl.
Subject Codes: N/A
CAB: 939676

Vegetation samples were collected in June and October, 1970 at varying distances from the Anaconda Aluminium Co. plant at Columbia Falls, Montana. Determinations were of foliar F. concn., injury index II (an estimate of gross amount of visible injury or "burn" for foliage of a given year), insect pest populations, and F concn. in insects collected within 0.5 mile of the Al reduction plant. Vegetation in control areas contained less than 10 ppm F, 11 was shown to be a conservative parameter of pollution since many samples with high F concn. did not show injury. F concn. in vegetation samples was used as the basis of pollution mapping, whereby the pollution index in "isopols" is equal to the local F conc. (with 10 as the background value). Visible injury occurred above 30 isopols (on a total area of 69000 acres) in susceptible species, viz. pines (Pinus albicaulis, P. contorta, P. monticola and P. ponderosa) and Douglas-fir (Pseudotsuga menziesii); the herb Smilacina stellata was a particularly sensitive indicator of F pollution. Nearly all vegetation was injured moderately at 100-300 isopols and (except grasses) severely at 300-600 isopols. Characteristic symptoms of F injury in conifers included enlarged cell nuclei and hypertrophy of resin-canal epithelium and vascular parenchyma.

965. CARLSON, C.E., GORDON, C.C., GILLIGAN, C.J. The relationship of fluoride to visible growth/health characteristics of Pinus-monticola, Pinus-contorta and Pseudotsuga-menziesii.
Fluoride, 1979, 12(1): 9-17

Subject Codes: N/A
BIO: 68017951

An intensive field study during the summer of 1977 near an aluminum plant in northwestern Montana, USA, was initiated to determine the relationship of foliar-accumulated fluoride to various growth/health characteristics of 3 commercially-important conifer species. Regression techniques were used to analyze the data obtained from nearly 110,000 needles. Increasing foliar concentrations of fluoride in P. menziesii were associated with decreased needle retention and length and with increased tip necrosis. Both mottle and tip necrosis of P. contorta increased in direct relation to the concentration of fluoride, whereas needle retention decreased. Tip necrosis and mottle of P. monticola also increased with foliar fluoride. No threshold foliar fluoride concentration was observed; adverse effects were visible on needles when their fluoride concentration reached 8-10 ppm, on a dry weight basis. Control concentrations were 3-5 ppm. No emission or ambient fluoride standard allowing detectable amounts of atmospheric fluoride will truly protect coniferous vegetation.

966. CARLSON, C.E., HAMMER, W.P. Impact of fluorides and insects on radial growth of lodgepole pine near an aluminium smelter in northwestern Montana - a preliminary inquiry.
Report, Northern Region, State and Private Forestry, USDA For. Service, 1974, No. 74-25: 14 pp.
11 ref.
Subject Codes: 6.1
CAB: 1455653

967. GARSED, S.G., RUTTER, A.J. Relative performance of conifer populations in various tests for sensitivity to SO2, and the implications for selecting trees for planting in polluted areas.
Imperial Coll., Silwood Park, Ascot, Berks., UK.
New Phytologist, 1982, 92(3): 349-367
11 ref., 7 fig., 7 tab.
Subject Codes: N/A
CAB: 1604144

968. HARVEY, G.W., LEGGE, A.H. The effect of sulphur dioxide upon the metabolic level of ATP.
Can. J. Bot., 1979, 57(7): 759-764
Subject Codes: N/A
BIO: 68043701

The ATP content of lodgepole-jack pine (Pinus contorta X banksiana) hybrids in the cordillerean-boreal transition zone was monitored during SO2 fumigations. Foliage was stabilized for analysis during the course of SO2 fumigations originating from a sour gas processing plant located in west-central Alberta (Canada). Controlled SO2 fumigations of seedlings were conducted in the laboratory to measure their effect upon ATP content. Field studies demonstrated that ATP concentrations of needle cells declined as SO2 concentration increased in the ambient air. An inverse linear relationship was found between ATP content and the measured SO2 concentration. The effect could be repeated in the laboratory with growth chamber cultured seedlings only in exceptional cases. It was repeated with detached branches from the field site exposed to SO2 under laboratory conditions. The results illustrate the fundamental differences between foliage preadapted to low-level SO2 fumigations and foliage grown under optimal conditions in a growth chamber.

969. HOVLAND, J., ISHAC, Y.Z. Effects of simulated acid precipitation and liming on nitrification in forest soil.
Intern Rapport, Sur Nedboers Virkning pa Skog og Fisk, 1975, No. IR 14/75: 15 pp.
5 ref.
Language: en
Summary Languages: no
Subject Codes: N/A
CAB: 630696

Simulated 'rain' (groundwater with pH 5.6 or artificially acidified to pH 4.0 or 3.0, at 25 or 50 mm/month) was applied to plots in a young Pinus contorta stand, 2-4 m tall, near Oslo. Some plots were also treated with lime at rates of 1500, 3000 or 6000 kg/ha. In laboratory experiments, nitrifying bacteria were found in all soils, but nitrification occurred only in soils receiving lime treatment.

970. KARENLAMPI, L., SOIKKELI, S. Morphological and fine structural effects of different pollutants on plants: development and problems of research.
Dep. Envir. Hygiene, Univ. Kuopio, Finland, 1979, No. TIM/SEM.9/R.9.: 8 pp. 19 ref.
Subject Codes: N/A
CAB: 1329547

Results are tabulated from various sources on ultrastructural injuries to leaf cells of several plant species, including: Pinus spp., P. contorta var. latifolia, Larix leptolepis, Picea abies and Abies alba. The pollutants responsible in these cases were SO2, NH3 and HF.

971. KROUSE, H.R. Sulfur isotope abundance elucidate uptake of atmospheric sulfur emissions by vegetation.
Nature (Lond.), 1977, 265 (5589): 45-46
Subject Codes: N/A
BIO: 78017285

972. LANG, K.J., NEUMANN, P., SCHUETT, P. The effect of seed source and fertilizing on sulfur dioxide sensitivity of Pinus-contorta seedlings.
Flora (Jena), 1971, 160(1): 1-9
Subject Codes: 1.4, 7.8
BIO: 52121478

973. LEGGE, A.H. Design of a gas exchange system for the study of the effects of sulfur dioxide on vegetation.
Can. For. Service, North. For. Research Centre, Info. Rep. NOR-X-72, 1973: 115-119
Subject Codes: N/A
BIO: 74068652

974. LEGGE, A.H. Primary productivity, sulfur dioxide, and the forest ecosystem: an overview of a case study.
Gen. Tech. Rep., Pacfic SW For. and Range Exp. Stn., 1980, PSW-43: 51-62
Subject Codes: 3.0
LISC: 577169

The objective of the West Whitecourt case study was to determine the consequence of chronic long-term exposure of a forest ecosystem to low concentrations of SO2 emissions originating from a "sour gas" processing plant in west central Alberta, Canada. A concept of ecologically comparable sampling site selection was developed and applied in the West Whitecourt study area. Lab and field measurements revealed a reduction in photosynthetic rate in lodgepole pine x jack pine (Pinus contorta x Pinus banksiana) in the field. Reduction of adenosine triphosphate (ATP) concentration in pine tissue during SO2 fumigation in the field followed by complete recovery after termination of SO2 fumigation and the disruption of mineral nutrient cycling in the forest ecosystem were observed. Basal area increment measurements of 200 lodgepole x jack pine trees from 5 ecologically comparable sampling sites revealed a decrease in wood production directly related to the presence of SO2 emissions. It is recommended that the concepts of the assimilatory capacity of the environment for S gas pollutants and irreversible ecological modification be utilized as measures of environmental quality.

975. LEGGE, A.H., JAQUES, D.R., AMUNDSON, R.G., WALKER, R.B. Field studies of pine, spruce and aspen periodically subjected to sulfur gas emissions. Water Air Soil Pollut., 1977, 8(1): 105-129

Subject Codes: N/A
LISC: 009982

Field studies of photosynthesis in Pinus contorta/P. banksiana (lodgepole pine/jack pine) hybrids, Picea glauca (white spruce) and Populus tremuloides (aspen) subjected to SO2 and H2S from a nearby natural gas processing plant were initiated near Whitecourt, Alberta, Canada during the summer of 1974. The site was characterized as a Pinus-Picea glauca/Arctostaphylos uva-ursi association (pine-white spruce/blueberry). A 15 m high scaffold was used as access to mid-crown foliage in the pines while the spruce and aspen were accessible from the ground. Net assimilation rates, transpiration rates and leaf resistances were calculated and water deficits were monitored. Photosynthetic rates measured were in a low range for the conifers studied, with pine having a maximum of 3.28 mg dm-2 h-1 and white spruce a maximum value of 2.3 mg dm-2 h-1. The low maximum photosynthetic rate determined for aspen is thought to be attributable to the onset of autumn. Chemical analyses for SO4-S using the methylene blue colorimetric method of Johnson and Nishita (1952) showed levels of 300 to 700 ppm, with the older foliage showing slightly higher values. Visible chronic SO2 symptoms had a pronounced sun, or upward, orientation. Ambient SO2, H2S and total S were measured using a Tracor 270HA Atmospheric Sulfur Analyzer (chromatographic method) and trends in ambient SO2 concentrations using an Envirometrics SO2 Analyzer (polarographic method). Concentration was found to be variable for SO2 and generally below 0.05 ppm. A concentration gradient of SO2 was found to exist in the lodgepole pine/jack pine stand with the SO2 values above the canopy generally higher than below the canopy (0.1 ppm above and 0.05 ppm below). This condition was occasionally reversed. The plant canopy is considered to act as a barrier to downward diffusion of the S emissions in the first case and also a barrier to upward diffusion of S emissions present due to advection in the stand in the second case. The vegetative environment surrounding the Windfall Gas Plant is definitely affected by S gas emissions but the extent remains to be determined.

976. LEGGE, A.H., BOGNER, J.C. 1983. Ecological monitoring of sulfur in forests in western Canada. Aquilo, Ser. Botanicas. 19(1):119-139.

977. LEGGE, A.H., JAQUES, D.R., et al. Sulphur gas emissions in the boreal forest: the West Whitecourt case study.
Water, Air, and Soil Pollution, 1981, 15(1): 77-85
Subject Codes: N/A
CAB: 1355262

This is part 1 of a four-year intensive case study, which in addition to studying ambient air quality at the site and stable sulphur isotopes at West Whitecourt Gas Plant, considers pine tree physiology and nutrition, plant biochemistry, ecological analogues and forest productivity.

978. LESTER, P.F., RHODES, E.C., LEGGE, A.H. 1986. Sulfur gas emissions in the Boreal forest. The west Whitecourt, Alberta, Canada case study IV. Air quality and the meteorological environment.

A program of atmospheric measurements was carried out in support of the west Whitecourt case study in the summers of 1975 and 1976. Measurements in and around an isolated stand of mature lodgepole times jack pine trees included temperature, moisture, and wind measurements at a climatological station outside the stand and at several levels on a 30 m radio mast tower within the stand. Sulphur dioxide concentrations were also measured on the tower. A number of short-term, intensive measurements were made to document the meteorological and SO2 environments in more detail, with special attention given to the transport of S gas from the source to the sink. The major source of SO2 at the intensive experimental site was very likely the flare stacks at the gas processing plant. Sulphur dioxide events at the study site were typically daytime, low concentration bursts of a few minutes in duration which occurred with westerly winds under fair weather conditions. Air impinging on the sand tended to flow around the edges of the stand, over the canopy, and into the trunk space. This aerodynamic effect, together with the uptake of SO2 by the vegetation, caused a minimum in SO2 concentration in the crown of the forest.

979. MCALLISTER, D.C. Hydrogen sulfide damage to lodgepole pine in Yellowstone National Park.
Proc. Mont. Acad. Sci., 1977, 36: 112 pp.
Subject Codes: N/A
BIO: 78007136

980. MALHOTRA, S.S. Effects of sulfur dioxide on biochemical activity and ultrastructural organization of pine needle chloroplasts.
New Phytol., 1976, 76(2): 239-245
Subject Codes: N/A
BIO: 62010352

The effects of aqueous SO2 on the ultrastructural organization of pine (Pinus contorta Dougl. var. latifolia Engelm.) chloroplasts and on their photosynthetic activity were determined under laboratory conditions. At aqueous concentrations of 100 and 500 ppm, SO2 caused swelling of thylakoid discs and disintegrated other intrachloroplast membranes, resulting in the formation of small vesicles (in older, matured tissues). Chloroplast structural injury was more pronounced in old tissues than in younger and more metabolically active tissues. The biochemical observations (Hill reaction activity) made on chloroplasts isolated from SO2-treated pine needle segments are in good agreement with the cytological observations.

981. MALHOTRA, S.S. Effects of aqueous sulfur dioxide on chlorophyll destruction in Pinus-contorta-var-latifolia.
New Phytol., 1977, 78(1): 101-109
Subject Codes: N/A
BIO: 63059377

The effects of aqueous SO2 on chlorophyll breakdown in lodgepole pine (P. contorta Dougl. var. latifolia Engelm.) were determined under laboratory conditions. Aqueous SO2 concentrations ranging 100-500 ppm resulted in a sharp decrease in total chlorophyll content. Chlorophyll (a) was more sensitive to SO2 than chlorophyll (b). Quantitative determinations of various pigments suggested that SO2 causes the conversion of chlorophyll (a) into phaeophytin (a) (100-500 ppm SO2) and chlorophyll (b) into chlorophyllide (b) (10-50 ppm SO2). The suggested conversion of chlorophyll into chlorophyllide induced by SO2 was supported by increased activity of pine needle chlorophyllase at low aqueous SO2 concentrations (10-50 ppm). The breakdown of chlorophyll molecules by SO2 as measured by loss of Mg++ and total chlorophyll was accompanied by a decreased ability of pine needles to photosynthesize H14CO3. The effect of SO2 on pigment breakdown and rate of photosynthesis was due mostly to the specific direct actions of SO2 and was not a function of increased activity.

982. MALHOTRA, S.S., KHAN, A.A. Effects of sulfur dioxide fumigation on lipid biosynthesis in pine needles.
Phytochemistry (OXF), 1978, 17(2): 241-244
Subject Codes: N/A
BIO: 66042162

Pine needle tissues incorporate acetate (1-14C) into phospho-, galacto- and neutral lipids. The major incorporation of the label among these lipids was always in the phosphatidyl choline (PC) fraction. The amount of label among the other lipid fractions varied depending on the age and source of the needle tissues (lodgepole (Pinus contorta var. latifolia) or jack pine (P. banksiana)). In general the biosynthesis of these lipids was more efficient in the developing than in the fully developed tissues. Treatment of the needle tissues with either gaseous or aqueous SO2 markedly inhibited their lipid biosynthesis. These effects were more pronounced in the developing than in the fully developed needles. SO2 concentration and length of exposure determined the extent to which the lipid biosynthetic capacity of the tissues was affected. Lipid biosynthetic capacity was partially or completely recovered when plants were removed from the SO2 environment. Plants exposed to moderate SO2 concentrations (0.18-0.20 ppm) for a period of 24 h recovered faster than those exposed to near lethal SO2 concentration (0.34-0.37 ppm) for only 1 hr.

983. MILLER, P.R., MILLECAN, A.A. Extent of oxidant air pollution damage to some pines and other conifers in California.
Plant Dis. Rep., 1971, 55(6): 555-559
Subject Codes: N/A
BIO: 52115819

984. PALANIYANDI, R., LEISER, A., PAUL, J. Effect of de-icing salt (NaCl) on 4 conifer species.
HortScience, 1979, 14(3): 409
Subject Codes: N/A
CAB: 1094752

Soil application of salt at high rates (8 tons/acre) damaged pine (Pinus jeffreyi and P. contorta), white fir (Abies concolor), and incense cedar (Libocedrus decurrens) after one season; after 2 seasons A. concolor and L. decurrens in particular were susceptible to lower rates of application. Foliar application (up to 0.5 M) damaged L. decurrens even at low rates in the second season.

985. RANFT, H., BELLMAN, C., FEILER, S., MICHAEL, G., TESCHE, M. Combined effects of SO2 pollution and frost on spruce in polluted regions.
Beitrage fur die Forstwirtschaft, 1979, 13(4): 160-165
21 ref.
Language: de
Summary Languages:
Subject Codes: 6.4
CAB: 1556789

Results are presented of growth chamber and field studies in E. Germany on effects of (a) SO2 exposure and (B) frost on 4 to 6-yr. old Norway spruce. Both (a) and (b) increased electrical conductivity of shoots and exudation of carbohydrates from roots (with an additive effect in the latter case); (a) at 1.2 ppm (but not 0.5 ppm) decreased frost hardiness (FH); (b) had no significant effect on gas exchange or content of carbohydrates or sulphydryl groups in SO2-exposed vs control plants. Ca fertilizer treatment increased FH. N.s.d. in FH was observed in late vs early flushing plants. At an SO2 polluted site with 4 Picea and 4 Pinus spp., greatest FH in midwinter was shown by Picea pungens and Pinus sylvestris.

986. SKOREPA, A.C., VITT, D.H. A quantitative study of epiphytic lichen vegetation in relation to SO2 pollution in western Alberta.
Info. Rep., Northern For. Res. Centre, Canada, 1976, No. NOR-X-161: 26 pp.
23 ref.
Language: en
Summary Languages: fr
Subject Codes: 3.5
CAB: 782906

An index of relative luxuriance/density was developed for the lichen flora of Pinus contorta stands near 2 sources of SO2 pollution that had been in operation for 3 years. Ordination and cluster analysis of the data distinguished 4 lichen communities, 3 of which were affected by the pollution. Mapping of the luxuriance/density values revealed the existence of a zone of severe damage 1.5-3 km from the pollution sources; moderate damage extended to a distance of 10 km. This index is shown to be more sensitive to recent changes in the flora than the Index of Atmospheric Purity which is based only on the number of species present.

987. TZSCHACKSCH, O. Breeding of pollution-resistant trees in East Germany.
Beitrage fur die Forstwirtschaft, 1981, 15(3/4): 134-137
9 ref.
Language: de
Summary Languages: ru, en
Subject Codes: 5.4, 7.0
CAB: 1556307

A review of research on: selection and propagation of "resistant" Norway spruce trees (exhibiting high needle vol. and radial increments) growing in heavily SO2-polluted areas; laboratory testing of relatively SO2-resistant provenances (correlated with low percent necrotic needles) for use in less heavily polluted areas; and testing of substitutes for Norway spruce (including: other Picea spp., Larix leptolepis, L. decidua, and hybrids; and Pinus contorta).

## 6.6 ANIMALS AND BIRDS

988. ANTHONY, R.M., BARNES, V.G. JR., EVANS, J. Vexar plastic netting to reduce pocket gopher depredation of conifer seedlings.
Proc. Vertebr. Pest Conf., 1978, (8): 138-144
Subject Codes: N/A
BIO: 17024513

989. BOAG, D.A., REEBS, S.G., SCHROEDER, M.A. 1984. Egg loss among spruce grouse inhabiting lodgepole pine Pinus contorta forests. Canadian Journal of zoology 62(6):1034-1037.

The loss of eggs from clutches deposited in simulated and natural nests of spruce grouse was investigated during the spring of 1983, in lodgepole pine forests of southwestern Alberta (Canada). Of all clutches, both in simulated and natural nests, 2/3 were partially or completely lost. density of simulated nests had no impact on proportional loss. Evidence suggests that nests under a conifer-dominated canopy, in an area lacking extensive shrub coverage and at distances > 15 m from trails were the most vulnerable to egg predators. Red squirrels were the principal predator destroying these clutches.

990. CROUCH, G.L. Susceptibility of ponderosa pine, Jeffrey pine and lodgepole pines to pocket gophers.
Northwest Sci., 1971, 45(4): 252-256
Subject Codes: N/A
BIO: 53058985

991. DAVIES, E.J.M. Red deer in Galloway.
Scottish Forestry, 1977, 31(3): 165-169
3 ref., 1 pl.
Subject Codes: 8.8.1
CAB: 928375

Red deer (Cervus elephas) were extinct in this part of Scotland by the 18th century. They were reestablished from park animals that escaped in the 1940's and the population has rapidly increased. A control scheme by shooting was begun in 1965 to avoid the need for fencing, to limit damage, to prevent expansion into the Borders and N. England, and to improve the quality of the deer. The scheme has generally succeeded, but in some places damage to Pinus contorta has been unacceptably severe, Picea sitchensis has been attacked, and Picea abies cannot be used for planting.

992. EDSTEDT, K.G. The risk of vole damage in Pinus contorta regenerations.
Inst. Viltekologi, SLU, Uppsala, Sweden, skogen, 1979, No. 6: 54-55
2 pl.
Language: sv
Summary Languages:
Subject Codes: N/A
CAB: 1071860

A summary of the results of a survey made in about 100 regenerations at Halsingland and Harjedalen, central Sweden, in 1977 and 1978. Fatal or serious damage by voles (mainly Microtus agrestis) was found in 10% of the area on 26% of the seedlings. The risk was greatest on damp sites with abundant vegetation and in areas recently cleaned. Seedlings in burnt or ploughed areas remained undamaged.

993. ELLIOTT, P.F. Evolutionary responses of plants to seed-eaters. Pine squirrel predation on lodgepole pine.
Evolution, 1974, 28(2): 221-231
14 ref.
Subject Codes: 5.4
CAB: 409486

Observations made during summer 1971 and 1972 in the Cascade Mts. in SW British Columbia, showed that Tamiasciurus hudsonicus discriminates in its feeding behaviour among the cones of Pinus contorta. Multiple regression analysis showed that a squirrel's preference for a particular cone phenotype is based on cone width, the number of viable seeds per cone, the ratio of total seed weight to cone

weight, and the shape of the cone in relation to its attachment to the branch. Evidence indicates that pine squirrel predation has resulted in selection for an increased number of seed-scales per cone, while keeping seed size relatively constant and reducing the number of seeds per cone.

994. HANSSON, L., BOSTROM, U. Vole damage in Pinus contorta plantations.
Sveriges Skogsvardsforbunds Tidskrift, 1979, 77, 5/6: 19-25
2 pl.
Language: sv
Subject Codes: N/A
CAB: 1147092

An account is given of damage by Clethrionomys glareolus and Microtus agrestis reported from various P. contorta plantations in central and N. Sweden since 1970. The incidence of damage was greatest in 1973-74 and 1977-78. It is estimated that on sites where the risk is greatest (usually those with the highest productivity) about 1/4 of the plants will be lost during a peak year of attack. On these sites Norway spruce, provided that it can cope with the climate, could be a better alternative.

995. HEWSON, R. Browsing by mountain hares lepus-timidus on trees and shrubs in northeast Scotland, Britain.
J. Zool. (Lond.), 1977, 182(2): 168-171
Subject Codes: N/A
BIO: 77088918

996. LINDSEY, G.D. The influence of animals on lodgepole pine regeneration. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 457-470
33 ref.
Subject Codes: N/A
CAB: 757672

Reviews the present limited knowledge of the interactions between birds and mammals and regeneration in the Pinus contorta ecosystem. Damage to seeds, seedlings and trees is described, and management practices that may influence this damage are considered.

997. MILLER, E., PARTRIDGE, A.D. The relationship of primary cavity nesters and decay. 36th Northeast Fish and Wildlife Conference, Providence, R.I., USA, April 1-4, 1979.
Trans. Northeast Sect. Wildl. Soc., 1979, 36(0): 60-68
Subject Codes: 8.8.1
BIO: 20046505

998. RADVANYI, A. Lodgepole pine seed depredation by small mammals in western Alberta.
For. Sci., 1971, 17(2): 213-217
Subject Codes: N/A
BIO: 52113351

999. ROLL-HANSEN, F., ROLL-HANSEN, H. Mouse damage to Pinus contorta and P. sylvestris.
Norsk Sogbruk, 1977, 23(10): 19
Language: no
Subject Codes: N/A
CAB: 984315

In a year of light infestation, 31 P. contorta vs. 1 P. sylvestris were severely damaged in a row planting of 2+1 transplants in a fertilizer trial with 1470 plants of each species. However, causes other than species for differences in attractiveness cannot be excluded.

1000. SALT, J.R., ROTH, C.A. Bark of pine galls eaten by red squirrels (tamiasciurus-hudsonicus).
Can. Field-Nat., 1980, 94(2): 196 pp.
Subject Codes: 2.4, 6.2
BIO: 19044244

1001. SULLIVAN, T.P. The effects of animal damage on spacing trials in natural stands of lodgepole pine. E.P. 845. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 57-58
Subject Codes: N/A
RCA: X1066

1002. SULLIVAN, T.P. 1984. Effects of snowshoe hare damage on juvenile lodgepole pine--implications for spacing natural stands. Research Note, Ministry of Forestry, B.C. No. 94. 27 p.

An 18-yr-old stand of Pinus contorta var. latifolia was thinned to 2x2 m spacing in 1979 and hare (Lepus americanus) damage and population density were recorded in 1979-83 in the thinned stand and in a nearby unthinned stand. The study period corresponded with the late increase, peak and decline phases of the 10-yr hare population cycle. Only 2.9% of crop trees were damaged in the first winter as hares fed on foliage from felled trees. Damage increased to 74.8% of trees the following winter and then decreased to 18.5 and 14.3% during the 3rd and 4th winters respectively. Overall, 18.1% of the trees in the thinned stand were girdled or semi-girdled (more than or equal to 50% of circumference) compared with 30.1% in the control stand. Smaller trees (60 mm D.B.H.) were more frequently damaged than larger trees. Recommendations are given for alleviating damage.

1003. SULLIVAN, T.P. 1985. Small mammal damage agents which affect the intensive silviculture of lodgepole pine. Pages 97-105 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Feeding damage by the snowshoe hare, red squirrel, and porcupine may adversely affect seedling and sapling stages of lodgepole pine silviculture. Hares browse seedlings and, along with squirrels and porcupines, bark and girdle pole-size trees. Pocket gophers and voles also inflict feeding damage on seedlings. Snowshoe hare populations reach a peak in abundance every 9-10 years and cause serious damage to plantations in central and northern Alberta as well as some northeastern parts of British Columbia. Population reduction, mechanical habitat alteration, and standard chemical repellents have failed to control hares and their feeding damage. A biological repellent system based on predator odours and encapsulation in timed-release devices is currently being developed. Compounds from weasel family scent gland odours have been particularly effective in suppressing hare feeding on lodgepole pine seedlings. This area repellent system may also eventually be used for protection of pole-sized stands as well. Long-term studies of the impact of hare and squirrel damage on growth and yield in thinned stands of juvenile pine was begun in 1979 in the Prince George and Cariboo Forest Regions of B.C. Semi-girdling (sub-lethal) damage clearly suppressed diameter growth of crop trees in the first three years after thinning. Frequency of attack and proportion of girdled and semi-girdled trees were significantly related to diameter: hares prefer stems less than 60 mm d.b.h. whereas squirrels (and porcupines) prefer stems greater than 60 mm d.b.h. Thinning of juvenile stands should be coordinated with low hare populations to prevent damage and allow crop trees to grow beyond 60 mm d.b.h. before the next peak population. A silvicultural strategy for alleviation squirrel damage is currently being investigated.

1004. SULLIVAN, T.P., SULLIVAN, D.S. Barking damage by snowshoe hares and red squirrels in lodgepole pine stands in central British Columbia.
Canadian Journal of Forest Research, 1982, 12(2): 443-448
29 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1570143

In stands of lodgepole pine in British Columbia with stocking densities of 8,333-40,000 stems/ha with average diameter of 80.1-46.8 mm, the proportion of

potential crop trees damaged by hares (Lepus americanus) was 30%, and by squirrels (Tamiasciurus hudsonicus) 37.7%. The proportion of trees damaged by hares increased with stocking density, whereas squirrel damage decreased. The number of wounds made by hares also increased with stocking whereas those made by squirrels showed little difference. For both animals the average surface area of bark and cambium removed per wound increased with tree stocking.

1005. SULLIVAN, T.P., SULLIVAN, D.S. The use of alternative foods to reduce lodgepole pine Pinus-contorta seed predation by small mammals.
Journal of Applied Ecology, 1981, 19(1): 33-46
Subject Codes: N/A
BIO: 74074993

Lodgepole pine seed predation by deer mice and related small mammals has been studied at 3 interior areas of British Columbia, Canada. When the distribution and abundance of rodent seed predators was taken into account, the amount of seed damage was directly related to the relative density of animals. Deer mice and voles destroyed the majority ( 85%) of pine seed within 3 wk of application when the abundance of these rodents was .gtoreg. 5 animals/ha. In areas with prolonged low densities ( 3 animals/ha), lodgepole pine showed very good survival (60-70% after 3 wk). The use of sunflower seeds as an alternative food successfully reduced pine seed predation. A ratio of 2 sunflower seeds to 1 pine seed produced a range of 50-82% survival of pine seed after 3 wk and 42-72% after 6 wk compared with 12-15% and 8-19% survival of pine without survival. This technique could be used for direction seeding cutover forest lands in areas suitable for growth in lodgepole pine in North America.

1006. SULLIVAN, T.P., SULLIVAN, D.S. Influence of fertilization on feeding attacks to lodgepole pine by snowshoe hares and red squirrels. IN: The Forestry Chronicle.
Dec. 1982, Vol. 58, No.6: 263-266
Language: en
Summary Languages: fr
Subject Codes: 7.6.2, 7.8
RCA: X1134

Lodgepole pine (Pinus contorta Dougl.) shows favourable growth and yield responses to spacing (thinning) and potentially to fertilization, but is susceptible to feeding injuries by snowshoe hares and red squirrels. This study was designed to determine the incidence of animal damage to crop trees in a fertilized-spaced stand, compared with those in spaced only and control (unspaced) stands. The conclusion is made that hares and squirrels clearly prefer to feed on fertilized lodgepole pine stems over those in non-fertilized or unmanaged stands

1007. SULLIVAN, T.P., SULLIVAN, D.S. 1983. Use of index lines and damage assessments to estimate population densities of snowshoe hares. Canadian Journal of Zoology. 61(1):163-167.

The abundance of snowshoe hares in lodgepole pine stands in central British Columbia, Canada, was studies. Density estimates and related demographic information from the index lines were compared with a standard set of lines superimposed on a 9-ha grid. During the summer of a peak year in abundance, index line trapping provided reasonably accurate estimates of hare densities on a grid system. There was little variation in the demographic variables of reproduction, body weight and sex ration between line- and grid-sampled populations. Hare abundance and barking damage (feeding injuries to trees) were greater in heavily stocked stands of lodgepole pine than in lightly stocked stands. Index lines provide a rapid and economical survey method for censusing snowshoe hares in lodgepole pine stands.

1008. SULLIVAN, T.P., SULLIVAN, D.S. 1984. Influence of range seeding on rodent populations in the interior of British Columbia, Canada. Journal of Range Management. 37(2):163-165.

The influence of range seeding on rodent populations inhabiting cutover lodgepole pine forest land was studied in the interior of British Columbia (*B.C.), Canada. Both deer mice and voles were strongly attracted to an area seeded with grass mixture in the early spring, even though overwinter mortality had dramatically reduced the average density to <= 2 animals/ha. Five rodents as well as several seed-eating birds appeared on this seeded area; no animals

were recorded on a nearby control. Subsequent seeding experiments in the summer also produced significant increases (2-2.2 times) in rodent populations. success of range seeding in BC can be quite variable, possibly due to seed predation by mice and voles. Consequently, both the quality and quantity of seed remaining for germination and forage production may be radically altered.

## 7.0 S I L V I C U L T U R E

1009. ALEXANDER, R.R., WATKINS, R.K. The Fraser Experimental Forest, Colorado.
USDA For. Service Gen. Tech. Rep., Rocky Mountain For. & Range Exp. Stn., 1977, No. RM-40: 32 pp.
12 pl.
Subject Codes: 7.7, 8.4, 8.8.4
CAB: 1071373

Comprises the following sections: The forest; Research program; Research highlights (harvest cutting lodgepole pine, harvest cutting spruce-fir, thinning young lodgepole pine, watershed studies); Current research (watershed studies, levels of growing stock- young lodgepole pine, environmental factors affecting Engelmann spruce regeneration, Engelmann spruce seed production). Species lists of birds and mammals are given in appendices.

1010. GLEN, L.M. The silviculture and management of lodgepole pine in British Columbia.
Reid, Collins Nurseries Limited, Prepared for the Forest Research Council of B.C., 1982: 96 pp.
29 ref.
Subject Codes:
RCA: X1097

The objective of this study was to prepare an interpretive review of literature pertaining to the management and silviculture of lodgepole pine var. latifolia. This would be used as a basis for future research and field studies.

1011. HENDRICK, E. Site amelioration for reforestation.
Irish Forestry, 1979, 36(2): 89-98
7 ref.
Subject Codes: 7.6.1, 7.8
CAB: 1258865

The effects are discussed of harvesting, treatment of residues, cultivation and fertilizing (with P) on the growth of second-rotation conifers in Ireland, where the rate of annual reforestation will increase 10-fold in the next 10-15 years. Reforestation experiments laid down in 1976 in SE Ireland suggest fertilizing with up to 30 kg/ha P and ground preparation by ploughing or ripping; pre-crushing and discing of slash could reduce irregularities caused by windrowing. The belief that more demanding species can be used for second rotations following a pioneer such as lodgepole pine has not been confirmed in Ireland.

1012. LOTAN, J.E., ALEXANDER, R.R. Lodgepole pine. IN: Silvicultural systems for the major forest types of the United States.
Agriculture Handbook No. 445, Forest Service, USDA, 1973: 42-44
Subject Codes: N/A
RCA: X1008

1013. MESSNER, R.M. Lodgepole Pine management on the pumice soils of central Oregon.
Journal of Forestry, 1974, 72(2): 93-95
6 ref.
Subject Codes: 7.1, 7.7
CAB: 371715

A brief review of present regeneration and thinning practices in the management of Pinus contorta (var. latifolia) stands, in relation to increased utilization and increased demand for P. contorta products.

1014. SCHMIDT, W.C. Silviculture of northern Rocky Mountain subalpine forest ecosystems.
Project INT-1251, Forestry Science Lab., Bozeman, MON, 01 Oct 79 to 30 Sep
Subject Codes: 8.0
CRIS: 0045927

Objectives: Determine ecological and silvicultural principles for developing management practices that accelerate regeneration and growth, reduce insect

problems and enhance other multiple-use values in subalpine forest ecosystems of the northern Rockies. Approach: Link northern Rockies conifer regeneration probabilities to silviculture systems, wood utilization levels, site preparation, water use, and understory vegetation. Determine effects of intensive culture on larch and lodgepole pine forest on timber and associated research. Evaluate how seed production and seedling establishment and development are related to budworm dispersal and behaviour under different silvicultural systems and how these systems in turn can be used to reduce the vulnerability and susceptibility of conifer forests to the budworm. Determine how silvicultural practices are related to or modify losses from the mountain pine beetle and in turn how their combined effects impact yield capability and regulation or logepole pine forest. Progress: Subalpine forests of the intermountain and northern Rocky Mountain area are strongly influenced by natural and prescribed fires. The general effects of natural fire on forest flora of the mountain West were recently described. More spcific evaluations of prescribed fire in larch/ Douglas-fir forests showed that high intensity fires were not always needed for proper seedbed preparation, but light, spring fires seldom prepared adequate seedbed. Information has been published for 50 common tree, shrub, herb and grass species to assist wildlife and insect evaluations and forest management activities. The forest cover type description for larch forests was updated to provide more ecologically based delineations.

1015. WALKER, N.R., JOHNSON, H.J. Growth and regeneration response to various stand treatments in a mature lodgepole pine stand.
Info. Report, Northern For. Res. Centre, Canada, 1975, N. NOR-X-137: 22 pp.
12 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.1, 7.5, 8.4
CAB: 536339

In 1951, several different improvement, harvest and conversion fellings were applied to a dense, even-aged 84-year-old Pinus contorta var. latifolia stand in Alberta to determine suitable techniques for thinning, harvesting and regenerating this type of crop. After 10 years some of the treatments had produced small increments in gross volume, but others had resulted in volume losses while there were numerous deaths from sunscald and windfall; moderately successful regeneration had taken place on less than half the treated areas. The only treatment that can be recommended for mature stands of P.c. var. latifolia is clear felling.

1016. ZEHETMAYR, B.A. Lodgepole pine. IN: Afforestation of Upland Heaths.
Forestry Commission Bulletin No. 32. 1960: 70-75
Subject Codes: N/A
RCA: X1014

## 7.1 REGENERATION

1017. BELLA, I.E. Assessment of regeneration stocking standards used in Alberta.
Info. Rep., Northern For. Research Centre, Canada, 1976, No. NOR-X-167: 4 + 38 pp.
17 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 892340

Relations between d.b.h. and age, and crown width and d.b.h. were calculated from data for lodgepole pine (Pinus contorta var. latifolia) and white spruce (Picea glauca), in west-central Alberta. Minimum number of trees/acre and associated stocking percentages to ensure complete crown closure at half-rotation age (40 and 50 years resp.) were derived from these relations. Minimum stocking was calculated at 220 well- dispersed pine or 300 well-dispersed spruce per acre on medium and good sites. Seedling spatial pattern for both species was clumped, and it is suggested that the 4-m2 quadrat used at present should be replaced by one of 10-m2 for spruce and 12-m2 for pine. The corresponding minimum stocking percentages are 75% and 70% resp., compared with the present standard of 40% based on the 4-m2 quadrat.

1018. BELLA, I.E., DEFRANCESCHI, J.P. Assessment of regeneration stocking standards

used in Alberta: a follow-up.
Info. Rep., Northern Forest Research Centre, Canada, 1978, No. NOR-X-211: 24 pp.
8 ref.
Language: en
Summary Languages: fr
Subject Codes: 3.2, 5.2, 5.5
CAB: 1369026

Growth and size data were obtained from open-grown Pinus contorta var. latifolia and Picea glauca in 1977 and used to supplement data from the initial (1975) study. The minimum numbers of well-dispersed trees/ha required for complete site utilization (complete crown closure) at half rotation age (40 years for Pinus, 40 or 50 years for Picea) were 575 for pine, 610-720 for spruce sawlog stands, 900-1100 for spruce pulpwood stands. Seedling pattern for both species was generally clumpy. Appropriate minimum stocking percentage by 10 m2 quadrats) were: 65% for pine; 70-80% for spruce sawlog stands; and 90% for spruce pulpwood stands. Crown width decreased with increasing altitude. Relationships were developed to show, by stocking percent classes, the relative frequency of stocked quadrats with at least 1, 2, 3...6 established and acceptable seedlings.

1019. CLARK, M.B. Regeneration problems and their significance with lodgepole pine in the southern interior of British Columbia. IN: Forest Regeneration at High Latitudes: Experiences From Northern British Columbia.
School of Agriculture and Land Resources Mgmt., Univ. of Alaska. Misc. Rept. No. 82-1, 1982: 21-23
Subject Codes: N/A
RCA: X1012

1020. CLARK, M.B. The effect of feller-buncher/grapple-skidder logging on lodgepole pine cone distribution and regeneration. E.P. 820. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 40 pp.
Subject Codes: N/A
RCA: X1053

1021. CLARK, M.B. 1984. Lodgepole pine cone distribution after logging with feller buncher/grapple skidder. Research Note, Ministry of Forests, B.C. No. 92. 15 p.

Areas in interior British Columbia logged by this method (which involves removing stems with complete crowns to central topping and sorting areas) over the period 1975-78 were systematically sampled and type of seedbed, the number of open and closed cones on the ground and in the slash, number and species of seedlings by age class, site preparation after logging, etc. were recorded. Min. satisfactory stocking was found on 11 of 16 areas within 5 yr following disturbance. It was recommended that additional cone-bearing slash should be left on logged areas to ensure satisfactory stocking. Scarification was also recommended.

1022. COCHRAN, P.H. Natural regeneration of lodgepole pine in south-central Oregon.
USDA For. Serv. Research Note, Pacific NW For. and Range Exp. Stn., 1973, No. PNW-204: 18 pp.
8 ref.
Subject Codes: 6.4, 7.2
CAB: 371728

Gives results of experiments on the germination and survival of Pinus contorta var. latifolia and P. ponderosa seed in Mazama pumice soils. In screened seedbeds in three areas, viable seed failed to germinate in 1970 and 1972. In 1971, germination of P. ponderosa seed was much lower (2.3 and 3.5%) in the two areas that showed good germination for P. contorta seed (36.4 and 45.4%), and of 329 P. contorta seedlings only 48 had survived in spring 1972. Failure was attributed to damage to the seed after sowing, and to low night temperatures and frost heaving after germination. In 1971, P. contorta seed was sown in plots that had been (a) left untreated, (b) scarified, (c) rolled, and (d) scarified and rolled. Half of each plot was covered with light slash. Germination in the uncovered areas was very poor and none of the seedlings survived. Under slash cover, germination was in the order of d) 46.9%, b)d)a) 2.2% and seedling survival in the first season was in the order c) 12.5%, b)d)a) 0%. The implications of these results for the regeneration of P. contorta in south-central Oregon are discussed.

1023. CROSSLEY, D.I. Some observations on lodgepole pine regeneration after clearcutting in strips.
Can. Dep. Resour. and Dev. For. Br., Res. Div., Silvic. Leafl. 65, Ottawa, Ont., 1952: 3 pp.
Subject Codes: 7.5
RCA: X1016

1024. CROSSLEY, D.I. The ingress of regeneration following harvest and scarification of lodgepole pine stands.
Forestry Chronicle, 1976, 52(1): 17-21
3 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.5, 7.6.1
CAB: 619104

Describes a study in W. central Alaska of the regeneration of Pinus contorta on areas harvested 13-15 years previously; germination dates were determined from ring counts at ground level. Recruitment of seedlings lasted for 8-12 years (average 10 years) on areas that had been scarified after felling, but for 9-15 years (average 12 years) on unscarified areas. Increasing the time between felling and scarification resulted in more erratic regeneration. These results suggest that the timing of a regeneration survey should not be decided arbitrarily, but should be based on knowledge of the probable regeneration rate for the area, so that the best estimate of ultimate stand establishment is obtained.

1025. EDGERTON, P.J., MCCONNELL, B.R., SMITH, J.G. Initial response of bitterbush to disturbance by logging and slash disposal in a lodgepole pine forest.
Journal of Range Management, 1975, 28(2): 112-114
13 ref.
Subject Codes: N/A
CAB: 536583

Reports the effect of selective fellings in Pinus contorta stands at 4300 ft. alt. in central oregon on the Purshia tridentata understory, used as summer forage by deer (Odocoileus hemionus hemionus). Line surveys before and ca. 2 years after logging showed extensive ground disturbance resulting from bulldozing of slash for burning, with loss of 71% of the P. tridentata cover. Regeneration of P. tridentata was abundant (pointing to a recovery of production in 5 years) and that of Pinus contorta was probably adequate (526 trees/acre). The use of hydraulic grapples to pile slash is suggested.

1026. EL-KASSABY, Y.A., MCLEAN, J.A. 1985. Identification of the origins of lodgepole pine seeds by X-ray energy spectrometric determination of mineral profiles. Forest Science. 31(3):539-551.

Elemental profiles for 20 certified and one unknown sample of seeds from Yukon Territory (11) and British Columbia (9) were determined using energy-dispersive spectrometry. Three different multivariate techniques were used to analyse the spectral variables. Cluster analysis separated the N. and S. groups, and the unknown seedlot was correctly grouped with the nearest source seedlot. Discriminant analysis confirmed the clear separation between the N. and S. groups, and the provenance of the unknown seed was successfully determined using the derived discriminant function. Principal component analysis was used to generate synthetic composite variables, which were used in turn in analyses of variance and correlation. Analysis of variance allowed partitioning of the total variation at 3 levels: between regions (N. and S.); among seedlots within regions; and within seedlots. Clinal variation was demonstrated between the component scores and lat. and long.

1027. ENDEAN, F., JOHNSTONE, W.D. Prescribed fire to regenerate subalpine lodgepole pine.
Info. Report, Northern For. Res. Centre, Canada, 1974, No. NOR-X-114: 17 pp.
10 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.6.1
CAB: 419039

Describes a comparative study of the growth and survival of Pinus contorta seedlings established by different techniques on areas burned and unburned after logging in the sub-alpine forest region of Alberta. When preceded by burning, all

the regeneration methods tested resulted in stocking levels above the 40% stocking standard set by the Alberta Forest Service. Growth and survival were generally better on the burned areas. On unscarified, unburned sites, seedlings raised in containers were the most satisfactory. Because of the large quantity of seed available in slash-borne cones, scarification without burning would probably result in adequate re-stocking. A combination of burning and retention of P. contorta seed-trees did not appear promising as a regeneration method since the seed-trees proved to be neither sufficiently windfirm nor fire-resistant.

1028. GARFORTH, M.F. Mixtures of Sitka spruce and lodgepole pine in south Scotland: history and future management.
Scottish Forestry, 1979, 33(1): 15-28
8 ref.
Subject Codes: 8.0
CAB: 1130884

About 20000 ha of this mixture exist in the S. Scotland Conservancy. The majority of planting was between 1951-1970, the aim being for the pine to act as nurse for the spruce mainly on Calluna sites low in N, P and K that were considered marginal for spruce. Sitka spruce is now successfully established as pure stands on such sites by fertilizing with control of calluna by 2.4-D. The wide use of inappropriate lodgepole pine provenances which failed to control Calluna but caused check of Sitka spruce, together with silvicultural regimes which have tended to favour the pine, has led to dominance of the less commercially desirable pine. Three decisions have been identified as necessary for the future management of these stands, viz. on (a) thinning, (b) which enables these decisions to be made on the basis of: percent spruce in mixture; pine provenance; crop ht.; and ht. difference between the species.

1029. HART, G.E., DE BYLE, N.V., HENNES, R.W. Slash treatment after clearcutting lodgepole pine affects nutrients in soil water.
Journal of Forestry, 1981, 79(7): 446-450
14 ref., 1 pl.
Subject Codes: 3.2, 7.5
CAB: 1442606

Further results are reported on the effects of clear felling and four methods of residue disposal (near complete - bare soil or chip mulch, and conventional harvest - broadcast burned or burned in windrows). Samples of soil water were collected in W. Wyoming from 1973 to 1977 on an old growth area and an area felled in 1971. Samples from felled areas had a significantly higher concn. of Na, K, Mg, Ca and N (as NO3). Differences between methods of slash disposal were not consistent except that elements were more concentrated under burned windrows of debris, and phenol concn. under a chip mulch sometimes exceeded 1 mg/litre in the first year after treatment.

1030. HELLUM, A.K. Eight plantations of lodgepole pine in west central Alberta.
Forestry Chronicle, 1979, 55(3): 88-90
9 ref.
Language: en
Summary Languages: fr
Subject Codes: 5.2
CAB: 1431635

The growth of containerized and bare-rooted 3+0 stock of Pinus contorta was compared with that of wildings grown on similar sites over 6 years. Shoot/root ratios, root collar diameter and weight were significantly greater in wildings, and they showed slightly greater root collar diameter and weight than bare- rooted stock. Nursery-grown seedlings were taller than wildings for four years after outplanting, but wildings grew faster during this period so that height was similar after approximately 5 years. It is concluded that planted stock are unlikely to shorten rotation times in comparison to naturally regenerated seedlings. Needle and twig tissues from Pinus contorta (40-60 years old) on SO2 exposed sites contained greater amounts of S and Al but less Ca, Mg and P than control tissues. In soil, decreases in Ca, Mg, Fe, Na, K and P contents and increases in Al and S contents were noted.

1031. HELLUM, A.K., WANG, B.S.P. 1985. Lodgepole pine seed: seed characteristics, handling and use. Pages 187-197 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Through its unique silvical characteristics of serotinous cones, lodgepole pine (Pinus contorta Dougl.) stands often regenerate themselves overabundantly

following fire or logging, provided adequate site preparation has been carried out. However, in the absence of a sound forest management policy in the past, large insufficiently restocked or overstocked areas have been created and intensive efforts in reforestation and stand tending are required to correct the situation. To achieve this, a thorough knowledge of the cone and seed characteristics is essential. This paper reviews the state of the art on major seed problems and discusses their implications and future needs for intensive management.

1032. JOHNSTONE, W.D. 1984. Influence of stand edge on planted white spruce and lodgepole pine. Information Report, Northern Forestry Research Center. No. NOR-X-256. 19 p.

Plots in 4 areas in W. central Alberta, clear felled in 1961, 1969 or 1970, were planted with Picea glauca and Pinus contorta in June 1973 or 1974. Seedling samples were measured and weighed before and immediately after planting and after 1, 2 or 3 growing seasons at distances of 15, 346, 90, 137 and 183 m from the uncut stand edge. Neither growth nor survival could be consistently related to distance from stand edge, probably because of local variations in site conditions. The size of the area felled did not affect seedling performance.

1033. KAASA, J. Seedling losses in the regeneration of Scots Pine (Pinus sylvestris) and lodgepole pine (Pinus contorta).
Tidsskrift for Skogbruk, 1973, 81(4): 437-445
4 ref.
Language: no
Summary Languages: en
Subject Codes: 6.0, 7.5
CAB: 266793

In regeneration of Pinus sylvestris, damage by Phacidium infestans was less severe in frost and by Ascocalyx abientina (Scleroderris lagerbergii) on the buds and branches. Regeneration by shelterwood methods is recommended in preference to clear felling. In a comparison of plantations at three locations of both under comparable conditions, the % of unstocked plots attributable to frost damage and disease was 15-35 P. contorta and 50-86 for P. sylvestris.

1034. KOVALCHIK, B., BLAKE, G. The effect of piling and burning versus chop logging residues on natural regeneration of serotinous lodgepole pine forests.
Research Note, Montana For. and Conservation Exp. Stn., 1972, No. 11: 4 pp.
1 ref.
Subject Codes: 7.6.1
CAB: 122071

Describes a study in the two clear-felled areas in Pinus contorta forest in the northern Rocky Mountains to compare piling and burning and the Marden Brush Chopper, to determine which method of slash disposal results in the more favourable percent stocking. Three years after treatment there was no significant difference between the two methods as regards the amount of natural regeneration obtained, which mostly occurred in dense scattered patches, overall percent stocking being low. Piling and burning exposed large amounts of mineral soil, provided ample seedbeds and a moisture regime suitable for seed. On the other hand, chopping exposed little proper seedbed but released immense quantities of seed from the serotinous cones contained in the slash.

1035. LOTAN, J.E., PERRY, D.A. Effects of residue utilization on regeneration of lodgepole pine clearcuts. IN: Proceedings of the Symposium on Terrestrial and Aquatic Ecological Studies of the Northwest, March 26-27, 1976.
Cheney, USA, Eastern Washington State College, 1976: 125-133
26 ref.
Subject Codes: 1.5, 2.9, 7.2
CAB: 1032616

Four 8-ha clear-fellings in Pinus contorta were each divided into quarters where residues were (a) piled and burned, (b) broadcast burned, (c) chipped and spread or (d) chipped and removed. Equal portions of each quarter were then auger-planted, hand- seeded, or left to be seeded from nearby trees. After 2 years, seedling growth and survival on (a) and (b) were superior to that on sites (c) and (d). In (a) better growth and survival was found with planted seedlings; in (b) when hand seeded. Highest seedling densities were found on naturally seeded sites in (a) and (d).

1036. MCLEOD, A.J., RAPP, E. Reforestation in Alberta.
Agriculture and Forestry Bulletin, University of Alberta, 1978, 1(3): 8-13
Subject Codes: 4.2
CAB: 1487331

Survival, ht. growth and root length are tabulated for 2-yr-old Picea glauca, P. mariana, Larix laricina, L. occidentalis, L. sibirica, Pinus contorta, and P. ponderosa, growing in vegetated or non-vegetated silty clay or sandy loam in a controlled environment. Species preferences are also tabulated for drainage, soil texture, soil tension, light intensity, competition, and the effects of flooding. Non-vegetated silty clay soil gave the best survival, ht. and diam. growth when all species were considered together.

1037. MINORE, D., DUBRASICH, M.E. Regeneration after clearcutting in subalpine stands near Windigo Pass, Oregon.
Journal of Forestry, 1981, 79(9): 619-621
3 ref., 1 pl
Subject Codes: 7.6
CAB: 1431606

Between 1959 and 1962, 50 stands of mountain hemlock (Tsuga mertensiana) were clear felled; some were planted or sown with Shasta red fir (Abies magnifica), western white pine (Pinus monticola), Douglas-fir and ponderosa pine; others were left to regenerate naturally. Slash was burned on some units. In 1978 and 1979 stocking and regeneration were assessed on 25 sample plots; early restocking had been poor and slow. Stocking averages are shown for the 6 most important species (western white pine, lodgepole pine, mountain hemlock, Shasta red fir, ponderosa pine, and Pacific silver fir, (Abies amabalis) for the first 16 years after felling. Stocking variation by silvicultural treatment and significant correlations between regeneration and environmental variables are tabulated for these 6 species, and for Douglas-fir. Nine burned and sown plots had

significantly better stocking and less shrub cover than 7 that had been burned and planted, but regeneration was adequate regardless of treatment. Total regeneration was adequate regardless of treatment. Total stocking increased with slope and nearness to the opt. aspect azimuth of 23 deg., and decreased with alt. Western white pine stocking decreased with alt. and pumice depth, while mountain hemlock stocking increased with both these variables.

1038. MURRAY, M. 1983. Lodgepole pine: regeneration and management. General Technical Report, Pacific Northwest Forest and Range Experimental Station, U.S.D.A. Forest Service. No. PNW-157. 52 p.

The proceedings of a fourth international workshop sponsored by the Canadian Forest Service and the University of Alaska, held Aug. 17-19, 1982 in Hinton, Alberta. After an introduction by Gasbarro, A.F., there are 11 papers: Natural lodgepole pine in West-central Alberta (3 papers): Bella, I.E. Part I: Regeneration stocking. 5-7 (3 ref.) Johnson, W.d. Part II: Juvenile spacing. 8-14 (21 ref.) Yang, R. Part III: Fertilization. 15-19 (3 ref.) dhir, N.K. Development of genetically improved strains of lodgepole pine seed for reforestation in Alberta. 20-22 (3 ref.) Hellum, A.K. Seed production in Serotinous cones of lodgepole pine. 23-27 (19 ref., 1 pl.) Ferdinand, S.I. Site preparation for natural and artificial regeneration of lodgepole pine in Alberta. 28-31 (9 ref., 1 pl.) Ives, W.G.J. Insect and disease pests and allied problems affecting lodgepole pine in Alberta. 32-36 (46 ref.) Ranger, R. Land use conflict in west-central Alberta, particularly within the St. Regis (Alberta) Ltd. Forest Management Area. 37-38. Simak, M. a new method for improvement of the quality of Pinus contorta seeds. 39-41 (1 ref.) Alden, J.N.; Zasada, J. Potential of lodgepole pine as a commercial forest tree species on an upland site in interior Alaska. 42-48 (15 ref. 1 pl.) Martinsson, O. Lodgepole pine in the Swedish reforestation--problems and prospects. 49-52 (16 ref.)

1039. PERRY, D.A., LOTAN, J.E. Regeneration and early growth on strip clearcuts in lodgepole pine/bitterbush habitat type.
USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1977, No. INT-238: 7 pp.
10 ref.
Subject Codes: 7.5, 7.6
CAB: 1032585

Density, stocking and growth of Pinus contorta were measured in 1976 in areas of

Montana that had been strip clear-felled in 1963 and prepared by (a) burning slash in place or (b) windrowing by bulldozer to remove the top few cm of soil and all competing vegetation. Measurements were also made of trees established before logging and of similar trees in the adjacent forest canopy, to determine their response to release. Seedfall was determined with seed traps in 1963, 1965 and 1968. Density averaged 645 trees/ha (of which 30% was advance growth) in (a) and 1333 trees/ha in (b); stocking averaged 15% in (a) and 24% in (b). There was considerably variation between strips. Seed/seedling ratios were from 1876 to 6480 on (a) and 625 to 2160 on (b). The growth rate of seedlings established since logging was similar in (a) and (b). Leader growth averaged 23 cm on released trees and 15 cm on trees under the forest canopy. Significant seedling establishment occurred in only 3 of the 14 years following clear- felling.

1040. PERRY, D.A., MEYER, M.M., EGELAND, D., ROSE, S.L., PILZ, D. Seedling growth and mycorrhizal formation in clearcut and adjacent, undisturbed soils in Montana: a greenhouse bioassay.
Forest Ecology and Management, 1982, 4(3): 261-273
29 ref.
Subject Codes: 2.3
CAB: 1556468

Seedlings, including those of lodgepole pine, Douglas-fir and Engelmann spruce, were grown in soil from areas logged 13-15 years previously in which logging slash was windrowed by bulldozers (W), or windrowed by hand and burned (B), or in soil from adjacent, undisturbed forest (U). In general, seedlings in (W) or (B) were shorter and had fewer root tips than those in (U); effects on seedling weight were consistent. Treatment with N fertilizers eliminated size differences due to soil source.

1041. PITEL, J.A., CHELIAK, W.M., WANG, B.S.P. 1984. Changes in isoenzyme patterns during imbibition and germination of lodgepole pine (Pinus contorta latifolia). Canadian Journal Forest. Research. 14(5):743-746.

Isoenzymes of esterase (EST), glutamate-oxaloacetate transaminase (GOT), leucine aminopeptidase (LAP), and peroxidase (PER) were examined following various periods of imbibition and germination of lodgepole pine seeds. The acidic and basic isoenzymes of embryos, and roots and shoots of germinating seedlings were analysed by polyacrylamide gel electrophoresis. One major band of EST disappeared with imbibition, while some minor bands appeared and disappeared with imbibition and germination. Comparison of the roots and shoots after 7 and 14 days of germination showed several tissue-specific differences. The number of bands of GOT increased with imbibition and germination. The activity of 3 isoenzymes differed between the root and shoot tissues. One band of LAP disappeared with imbibition. The activity of 2 bands varied between the root and shoot tissues. The number of bands of PER increased dramatically following imbibition and germination. Many tissue-specific differences were observed between root and shoot tissues.

1042. ROBERTSON, S.U. The possible role of natural regeneration in Scottish forestry.
Scottish Forestry, 1976, 30(2): 134-142
Subject Codes: N/A
BIO: 76063191

1043. SHEARER, R.C. Regeneration establishment in response to harvesting and residue management in a western larch-Douglas-fir forest.
Gen. Tech. Rep., Inter. For. and Range Exp. Stn., 1980, INT-90: 249-269
Subject Codes: 4.2
LISC: 586606

Natural regeneration lagged on all sites on a recent logging study, because: (1) little mineral soil was exposed either during timber harvest or as a result of prescribed burning; and (2) in 1974 (year of logging) western spruce budworm destroyed nearly all cones except western larch. Seed dispersal usually occurred via thermal slope winds with uphill motion, beginning in Sept. However, in 1976 most seed was dispersed by erratic winds associated with a dry cold front in Oct. Less than 10% of the sound seed dispersal in the fall survived until germination. Germination and seedling survival of western larch, Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir was substantially higher on burned seedbeds than on unburned seedbeds. Subalpine fir was the only species that germinated relatively well on unburned duff. Surface temperatures were not critical on any treatment (except on charred surfaces the first year following prescribed burning), because competing vegetation quickly shaded all cutover areas,

Douglas-fir and Engelmann seedlings planted during 1976-78 have become established on all treatments. The effects of residue utilization on understory and seedbed treatments may be more important in the later growth of conifers than in the establishment stage.

1044. SOLBRAA, K. Artificial regeneration of burned areas - preliminary results. Nisk (Nor Inst Skogforsk) Rapp 0(7), 1981:
Subject Codes: 6.0, 7.8
BIO: 74017057

The aim of the project was to find methods for establishment of new stands with an acceptable initial growth after wild fires on low productivity areas. In this report special emphasis is devoted to a description of damages, harmful insects and the fungus Rhizina undulata. These organisms may kill or damage a great share of pine (Pinus contorta) seedlings planted during the first 2 yr after the fire, especially on coarse sand. Different insecticides and a fungicide are tested and gave a good protection. These experiments will be repeated in new areas. After the 1st few years, it may be desirable to increase the nutrient supply for the plants. The use of easily soluble fertilizers gave a short-term affect only at this stage. Soil improvement and fertilization greatly increased the growth for at least 4 yr. Experiments are started with slowy soluble fertilizers and plant species associated with N fixing bacteria.

1045. STERMITZ, J.E., MURRAY, K.G., et al. Soil characteristics influencing lodgepole pine regneration near west Yellowstone, Montana.
USDA For. Serv. Res. Pap. INT-163, 1974: 16 pp.
Subject Codes: 3.6, 4.2, 7.2
RCA: X1015

In direct seeding from soils of volcanic origin, seedbed preparation treatments affected germination and first-year survival insignificantly, compared to site differences. A strong positive relation between survival and the amount of silt plus clay in the soil was identified. Available potassium and total nitrogen had a negative influence, attributable to poor seed-soil contact and competition for moisture on more fertile sites. The three soil properties explained 93% of the variance in seedling survival. A response surface for the three soil properties was developed, as an aid in predicting survival.

1046. STRICKLER, F.S., EDGERTON, P.J. Emergent seedlings from coniferous litter and soil in eastern Oregon.
Ecology, 1976, 58(4): 801-807
14 ref.
Subject Codes: 7.5
CAB: 843441

Litter and soil samples from three mixed conifer forests (dominant trees: Abies grandis, Pinus contorta, Picea engelmannii, Larix occidentalis and Pseudotsuga menziesii) were subject to various heat and light treatments in a greenhouse study. A total of 536 seedlings emerged during 1 yr comprising 38 species including 4 shrubs; no conifer seedlings emerged. The results are discussed in relation to post-logging management.

1047. VIETNIEKS, K.A. 1985. A site and microsite factor approach to evaluating seedline distribution and establishment of lodgepole pine on drag scarified cutover in the Prince George Forest District. (Thesis summary). Forestry Abstracts. 46(10):642-643.

1048. VYSE, A., NAVRATIL, S. 1985. Advances in lodgepole pine regeneration. Pages 173-186 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Successful regeneration of lodgepole pine is still an art, but the attainment of target stands with sufficient numbers of healthy, well-distributed seedlings has been made more attainable by scientific and operational advances since the 1973 symposium. Clearcutting is still the predominant method used to regenerate stands of lodgepole pine, and partial cutting practices are restricted to use in special situations, particularly in the southern part of the natural range. In all areas successful natural regeneration depends upon the manipulation of seed supply and exposure of mineral soil. methods for estimating seed supplies, and improvements in site preparation techniques, have increased the ability of silviculturists to achieve an optimum combination of seed supply and seedbed over a wide range of sites. Excessive stocking is a

larger problem than inadequate stocking in Canada. Artificial regeneration by means of direct seeding is used very little, but new spot seeding techniques coupled with seed protection from rodents could lead to a resurgence of interest because of the relatively high costs of planting. Planting efforts have increased substantially as a means of both replacing pine stands and displacing other species. ease of establishment, precise stocking control, rapid early growth, and the promise of shortened rotations are the major attractions. Results are usually excellent but there have been some problems in nursery practices. Early root development in planted stock is another related major concern. Continued progress in regeneration, whether natural or artificial, is highly dependent on systematic reviews of performance.

1049. YING, C.C., MURPHY, J.C., ANDERSEN, S. 1985. Cone production and seed yield of lodgepole pine grafts. Forestry Chronicle. 61(3):223-228.

Production records over a 12-yr period of 2 clone banks established in an orchard in central British Columbia in 1972 are given and discussed. Seed and pollen cone production increased rapidly to a peak in 1982, declined in 1983 and recovered in 1984. In 1982, on ave each living graft produced 237 seed cones and 185 pollen cones. There were large, persistent differences among clones. Clones from the Yukon and N. British Columbia started to produce seed before those of more southerly origins, although the latter eventually outproduced them. Ave mature cone length was 41 mm, width 24 mm, wt. 7 g. There were 23 seeds per ave cone, and 100 seeds weighed 0.4 mg. Ave germination was 86%.

## 7.2 SEEDING

1050. ABOUGUENDIA, Z.M., REDMANN, R.E. Germination and early seedling growth of four conifers on acidic and alkaline substrates.
Forest Science, 1979, 25(2): 358-360
8 ref.
Subject Codes: 3.6, 7.4.4, 8.8
CAB: 1146791

A study of the effects of buffered solutions (pH 2.2, 3.0, and 9.0) on seed germination and early seedling growth. At low pH, germination of lodgepole pine was higher, white spruce and jack pine equal to, and black spruce lower than that

at the reference (R, distilled water, pH 6.5). Extreme alkaline conditions (pH 9.0) reduced germination of all species compared to R. Seedling growth of all species was significantly less at high and low pH than at R, lodgepole pine showing better growth at pH 9.0 than other species, and jack pine better growth at pH 3.0. These results are relevant to species selection for revegetation of mining waste sites. From authors' summary.

1051. BASARABA, D. Evaluation of the shelter cone seeding method of direct seeding in the east Kootenays.
IN: SISCO Spring Newsletter, 1983, Southern Int. Silviculture Committee, Nelson, B.C., 7 pp.
Subject Codes: N/A
RCA: X1108

Shelter cone seeding was tested on 29 sites in the East Kootenays. This method holds promise as a cost-effective and viable direct seeding technique on some sites. The number of seeds per cone, damaging agents, seedling germination and survival were studied with respect to seed wafers and plantations.

1052. CARLSON, L.W. BELCHER, J. Seed treatment fungicides for control of conifer damping-off: laboratory and greenhouse tests 1968-1969.
Can. Plant Dis. Surv., 1970, 50(2): 63-73
Subject Codes: N/A
BIO: 52086429

1053. CAYFORD, J.H. (Editor). Direct seeding symposium, Timmins, Ontario, September 11, 12, 13, 1973.
Canadian Forestry Service, 1974, No. 1339: 178 pp.
many ref.
Subject Codes: N/A

CAB: 390787

Comprises 17 papers (in English, with French summaries and separate sets of references) presented at the symposium, which was sponsored jointly by the Canadian Forestry Service and the Ontario Ministry of Natural Resources. Three papers are concerned with aspects of direct sowing in the north-eastern USA, previously discussed at the symposium at Amherst, Mass., in 1964. The other papers are concerned with Canada, and the volume as a whole gives an outline of the present status of direct sowing in that country, summarizes the results achieved so far and indicates the problems that remain to be solved. At present, direct sowing is used on ca. 10% of the acreage included in the Canadian artificial regeneration programme. Success has been variable, being achieved quite consistently with Pinus banksiana, but rarely with Picea mariana, Pinus contorta, Pinus strobus and Picea glauca.

1054. EDWARDS, D.G. Effect of a soil wetting agent on germination of four important British Columbia conifers.
Forestry Chronicle, 1973, 49(3): 126-129
8 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 226439

Germination tests were made with seeds of Pseudotsuga menziesii, Pinus contorta, Picea glauca and P. sitchensis placed on filter paper and continuously irrigated with four concentrations (from 0.001 to 1%) of 'Soil Wet' (an alkyl aryl polyethoxyethanol currently used in container soil mixtures to make hydrophobic constituents wettable). Germination was completely inhibited in all four species at the 1% concentration. With a 0.1% solution, i.e. the concentration recommended by the manufacturers, the reduction in germinative capacity was 46% for Picea sitchensis and between 5 and 11% for the other species; radicle lengths were also reduced. No phytotoxic effects as judged by germination or seedling size were observed in any of the species when treated with solutions of concentrations less than or equal to 0.01%.

1055. EL-LAKANY, M.H., SZIKLAI, O. Effect of seed extracts on radiosensitivity.
Silvae Genetica, 1975, 24(4): 113-115
10 ref.
Language: en
Summary Languages: de
Subject Codes: N/A
CAB: 594671

Describes laboratory experiments in Vancouver to study the relative sensitivity to gamma-irradiation of seeds of Pseudotsuga menziesii and Pinus contorta soaked in extracts of seeds of these species vs. seeds soaked in water or kept dry. At a lower dose of radiation (1000 R), soaking seeds in extracts before irradiation stimulated germination. Seed extracts appeared to have a radiosensitizing effect at higher doses of radiation in both species; this effect was apparently related to processes within the seed, since it was very slight when, in one treatment, the seeds were not themselves irradiated but were soaked in extracts that had been irradiated. Experiments are planned to investigate whether these effects are related to systems in the embryo or in the endosperm.

1056. FRYK, J. "Biological" sowing experiments at AB Iggesunds Bruk in 1977-1978. Results and practical recommendations.
Sveriges Skogsvardsforbunds Tidskrift, 1979, 77(2): 59-68
Language: sv
Subject Codes: 4.2
CAB: 1071441

A series of experiments was performed on Scots pine (Pinus sylvestris) and lodgepole pine (P. contorta) at Halsingland and Harjedalen, central Sweden. Two sowing methods were used, viz. broadcasting on patches and drilling in furrows made by a FIAB harrow, and the effects on seedling survival of factors such as soil type, alt., sowing date and covering materials were examined. Preliminary results after 1 or 2 growth periods are tabulated. On average, emergence was better for the native P. sylvestris than for P. contorta, but the difference had decreased by 1978, owing to delayed germination of P. contorta. The best results were obtained on moist permeable soil. Of the covering materials tested, only gravel (2-4 mm fraction) enhanced emergence. Seedling survival of both species was satisfactory even at 500-600 m alt. but in both these cases site preparation is particularly important. In central Sweden the sowing season should not

continue beyond mid to late July, because in later sowings the risk of failure increases rapidly.

1057. GORDON, A.G., WAKEMAN, D.C., GHAZAL, H. Trials of the fluid drilling techniques on conifer seeds.
Res. Info. Note, Forestry Commission, UK, 1979, No. 48: 4 pp.
Subject Codes: N/A
CAB: 1229567

Laboratory and nursery trials in Britain showed that the method used to prepare seeds for fluid drilling (sowing pre-germinated seeds in a gel) gave the same final germination % as a simple modification of the standard Forestry Commission pre-sowing chilling treatment (modified by 'naked incubation' of the chilled seeds in plastic bags at 23 deg C). The pregermination in both methods increased the speed of germination resulting in increased ht. growth of Sitka spruce and lodgepole pine by the end of the season. The gel used in fluid drilling had no adverse effect on sowing. Water incubation of chilled seed reduced germination. Another account of a study of forage use by the Rocky Mountain elk (Cervus elaphus (Canadensis) nelsoni) in 1971 and 1972 in an area of ponderosa pine, Douglas-fir, or subalpine fir (Abies lasiocarpa) as climax species, with western larch (Larix occidentalis), Engelmann spruce, lodgepole pine, and whitebark pine (Pinus albicaulis) as seral (and often dominant) species. Approx. one third of forage was browse and included Populus tremuloides and P. trichocarpa (from feeding site observations), and whitebart and lodgepole pines and Douglas-fir (from rumen analysis).

1058. HOCKING, D. Effects of stratification of Alberta white spruce and lodgepole pine seeds on emergence in operational seedbeds.
Bi-monthly Research Notes, 1972, 28(4): 26-27
5 ref.
Subject Codes: N/A
CAB: 067799

Experimental sowings of stratified and non-stratified seed of Pinus contorta var. latifolia showed significantly better results from unstratified seed, which confirmed the current practice of not stratifying seed of this species. Picea glauca seed, on the other hand, which is currently stratified before sowing, gave very complex and inconsistent results, some significantly superior performance being shown in different seedlots by stratified and by unstratified seed. No clinal variation could be discerned, and it is recommended that, until the situation has been further elucidated, seed of P. glauca from Alberta (var. albertiana) should not be stratified.

1059. KAMRA, S.K. Studies on Pinus contorta (Doug. ex Loud.) seed germinated at different temperatures. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 287-298
15 ref.
Subject Codes:
RCA: X1093

This paper deals with a comparison of the percentages and the rates of germination of nine samples of Pinus contorta seed at 10, 20 and 20-30 deg. C on Jacobsen apparatus.

1060. KAUFMANN, M.R., ECKARD, A.N. Water potential and temperature effects on germination of Engelmann spruce and lodgepole pine seeds.
For. Sci., 1977, 23(1): 27-33
Subject Codes: N/A
BIO: 64026401

The effects of water stress and temperature on seedling emergence from soil or germination in solutions were studied on Engelmann spruce (Picea engelmannii) and lodgepole pine (Pinus contorta). Seed emergence or germination was reduced by low water potentials both in soil and in polyethylene glycol solutions. Emergence from soil was about equal at 16 deg. and 25 deg. C, but reduced at 35 deg. C. The time lags before initial emergence or germination were similar for both species, and low water potentials resulted in longer time lags. However, the time required for 25% emergence at 16 deg.C was about 2 days longer for pine than for spruce. These data suggested that Engelmann spruce establishment may occur more rapidly than that of lodgepole pine in cool environments. Seedling emergence was similar using 2 nursery soils which differed widely in their effects on subsequent seedling growth.

1061. LEADEM, C. The effect of soaking seeds on germination of some major B.C. forest trees. E.P. 835. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 15
Subject Codes: N/A
RCA: X1044

Results show that white spruce, lodgepole pine, and western hemlock seeds germinated about the same whether they were pre-soaked or not. Amabalis fir, Sitka spruce, and Douglas-fir seed germination was significantly improved when soaked prior to stratification. Seeds germinated equally well if soaked for 16, 24, or 32 hours, but germination declined slightly if soaked for 48 hours. The effects of different presoaks were not enough to merit changing the standing 24-hour soaking period currently prescribed for B.C. forest tree seeds.

1062. LEDGARD, N.J. Research into the direct seeding of woody plants in high country revegetation.
New Zealand J. For., 1976, 21(2): 253-264
Subject Codes: 7.4.4
BIO: 63068660

Revegetation of high country by direct seeding with woody species was investigated in the Craigieburn Range (New Zealand), using Pinus contorta, P. mugo, and Alnus viridis. Cover was essential to protect seedlings from extreme climatic effects, particularly winter frost heave, and the most practical way of providing cover was with a sown sward of grasses and legumes. Although survival of P. mugo on bare ground was assisted by the application of a complete fertilizer mix, on sward-covered ground high rates of fertilizer increased interplant competition and depressed the survival of tree seedlings. Tree seed pelleting with a variety of nutrients did not improve seedling survival or growth. In pot trials mycorrhiza development in the roots of pines greatly increased seedling growth. Coating seeds with basidiospores of these fungi has not, so far, proved a practical means of field inoculation. Spring sowings were more successful than autumn sowings except on sites covered with snow throughout the winter.

1063. LEDGARD, N.J. Direct seeding of trees and shrubs. IN: Revegetation in the Rehabilitation of Mountain Lands.
FRI Symposium, New Zealand Forest Service, 1978, No. 16: 153-160
Subject Codes: N/A
CAB: 1203559

An account of direct sowing trials with (a) Pinus mugo, (b) P. contorta and (c) Alnus viridis at 990-1240 m alt. in the Craigieburn range. Most sites where establishment was successful had some depleted shrub or grass cover to protect seedlings from extremes, especially frost heave; temporary herbaceous cover was essential for winter survival on bare sites. Survival of (c) above 1000 m was poor; (a) survived better than (b) after 15 months on all sites. Mycorrhizal inoculation and the equivalent of 50 kg/ha each of N and P increased DM of (a) seedlings by over 50% in greenhouse experiments; appropriate methods have yet to be developed for field application.

1064. LOCK, W., SUTHERLAND, J.R., SLUGGETT, L.J. Fungicide treatment of seeds for damping-off control in British Columbia forest nurseries.
Tree Planters' Notes, 1975, 26(3): 16-18, 28
7 ref.
Subject Codes: N/A
CAB: 584994

Describes field trials to test the value of eight fungicides in preventing pre- and post- emergence damping-off in seeds and seedlings of Pseudotsuga menziesii, Picea sitchensis, P. glauca and Pinus contorta. Fungicides were applied to the seeds by different methods (described) and the seeds were sown in 1971, 1972 and 1973. Results (tabulated) show that none of the fungicides tested gave a consistent increase in plant survival; they could, however, be used to prevent severe losses in years when damping- off is endemic. Benlate, although ineffective against Pythium and Phytophthora, is recommended because it is less phytotoxic than the more commonly used captan. Since soaking seeds in fungicide proved ineffective, the problem of achieving uniform seedling densities with pelleted seeds remains. Further research is recommended.

1065. PROCHNAU, A.E. Direct seeding experiments with white spruce, alpine fir, douglas-fir, and lodgepole pine in the central interior of British Columbia.
British Columbia Forest Service, Research Note No. 37, 1963; 24 pp.
40 ref.
Subject Codes: 7.1
RCA: X1074

The purpose of this work is to evaluate the possibilities of obtaining regeneration by natural means and by direct seeding of tree species of the spruce-alpine fir forests in the central interior of British Columbia.

1066. REDMANN, R.E., ABOUGUENDIA, Z.M. Germination and seedling growth on substrates with extreme pH laboratory evaluation of buffers.
J. Applied Ecol., 1979, 16(3): 901-907
Subject Codes: 7.4.4
LISC: 473942

Germination and early seedling growth of Pinus contorta and Picea glauca were examined, using distilled water (pH 6.3), eight acidic buffer solutions (pH 2.2), and eight alkaline buffer solutions (pH 9.0). Four of the acidic buffers significantly increased germination of P. contorta, as compared to the control (distilled water, pH 6.3). All but one alkaline buffer significantly reduced germination of P. contorta. All but 2 of the 16 buffers significantly reduced germination of P. glauca and 5 buffers totally inhibited germination. Seedling growth of P. contorta at pH 2.2 varied between 10 and 43% of the control, and at pH 9.0 varied between 0 and 59% of the control. The equivalent seedling growth of P. glauca was 0-28%, respectively. Citric acid-potassium hydrogen phosphate was the most stable and physiologically innocuous acidic buffer; glycine- sodium hydroxide was the most innocuous alkaline buffer. The osmotic potential of citrate-phosphate buffers was varied, using polyethylene glycol. The results indicated that the osmotic potential of the buffers was not low enough to explain reductions in germination and seedling growth; the components of the buffer were apparently toxic. The results are applicable to the revegetation of mine spoils and tailings, affected by extreme acidity or alkalinity.

1067. SUTHERLAND, J.R., EDWARDS, D.G.W. Pigments for use on conifer seeds sown in forest nuseries.
Report, Pacific For. Res. Centre, Canada, 1976, No. BC-X-146: 12 pp.
11 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 710477

Trials of three commercial seed-applied pigments (yellow, blue and red) showed no significant effect on germination and seedling growth in Pseudotsuga menziesii, Picea sitchensis, P. glauca, Pinus contorta and Tsuga heterophylla.

1068. SUTHERLAND, J.R., WOODS, T.A.D., et al. Dusting seeds with aluminum powder.
Tree Planters' Notes, 1978, 29(3): 14-16
3 ref.
Language:
Summary Languages:
Subject Codes: N/A
CAB: 1380409

Aluminium powder has recently been used as a seed lubricant and animal repellent in direct-sowing trials. A study was made of the effects of Al powder on germination, growth and survival of seeds of Sitka spruce, white spruce, lodgepole pine and coastal and interior forms of Douglas-fir. It was found that Al powder significantly reduced germination of all species except interior Douglas-fir. Survival was not affected. shoot growth was less in both forms of Douglas-fir and in white spruce; Sitka spruce and lodgepole pine were unaffected. Drill performance was not improved by Al powder.

1069. SUTHERLAND, J.R., WOODS, T.A.D., ILNYTZKY, S. Pesticide phytotoxicity: studies with seeds, germinants and seedlings of British Columbia conifers.
Report, Pacific Forest Research Centre, Canada, 1977, No. BC-X-165: 7 pp.
Subject Codes: 6.5
CAB: 914835

The petroleum weedkillers AWK No. 1 and AWK No. 1 Special, the insecticides diazinon, trichlorphon, malathion and carbaryl and the fungicides benomyl, fenaminosulf and Neutro Cop '53' were applied to 5 developmental stages of Pseudotsuga menziesii, Picea sitchensis, Picea glauca, Tsuga heterophylla and Pinus contorta in greenhouse and field experiments. The 2 weedkillers were toxic to most stages of most species in the greenhouse but not in the field. Fenaminosulf caused mortality and reduced growth of all species in the greenhouse and in the field. Benomyl caused no serious phytotoxic effects. Phytotoxicity decreased with increased seedling age.

1070. VAN DEN DRIESSCHE, R. Overwinter sowing of seed pelleted by Hilleshog. E.P. 786.07, 11. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 20
Subject Codes: N/A
RCA: X1045

## 7.3 NURSERY PRACTICE

1071. BOOTH, I.P. The production and use of tubed seedlings in Irish forestry.
Irish Forestry, 1977, 34(2): 91-98
4 ref.
Subject Codes: 7.4, 8.5
CAB: 914705

An account of the method and cost of production of seedlings of Picea sitchensis. Pinus contorta and Pinus radiata in open-ended, polystyrene tubes in a heated polythene tunnel. The most expensive part of the method was hand-cutting 'steps' in the side of ploughed furrows at the time of planting to protect the seedlings.

1072. BURDETT, A.N. Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine.
Canadian Journal of Forest Research, 1978, 8(4): 483-486
17 ref., 3 pl.
Subject Codes: N/A
CAB: 1071422

Lodgepole pine (Pinus contorta) seedlings were raised in containers (Styroblocks) painted with a root-growth inhibitor (exterior latex paint containing 0.1 kg/litre basic cupric carbonate). Contact with this wall coating completely inhibited the elongation of lateral roots, thereby preventing them from growing down or around the container wall. However, when the seedlings were planted, the inhibited lateral roots very quickly resumed growth. Consequently, the trees soon acquired a root system quite similar in basic form to that of a naturally established seedling. From author's summary.

1073. CANHAM, A.E. Effects of some environmental factors on tree seedling growth.
Applied Res. Sect., Dept., Agric. & Hort., Reading Univ., UK, 1976: 55-56
8 ref.
Subject Codes: 7.8
CAB: 796113

Plants of Picea sitchensis, Pinus contorta and P. nigra var. maritima were raised from seed in glasshouses, at 3 $CO_2$ concentrations, 2 daylengths and 2 rates of top dressing, and were hardened off after 16-20 weeks, before planting out in the forest. The effect of $CO_2$ was maximal at 10 weeks: increases in height varied from 14% at 1500 v.p.m. with P. contorta to 56% at 3000 v.p.m. with Picea sitchensis. Enriched plants were suitable for hardening off 11/2-3 weeks earlier than unenriched plants. Higher rates of top dressing caused an increased in seedling height of 9% at 16 weeks. These treatments also increased final stem diameter and final dry weight.

1074. CARLSON, L.W. Guidelines for rearing containerized conifer seedlings in the prairie provinces.
Info. Rep., Northern For. Res. Centre, 1983, No. NOR-X-214E: v + 64 pp.
32 ref., 11 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1514470

Particular reference is made to rearing white spruce, lodgepole pine and jack pine in Saskatchewan, Manitoba and Alberta.

1075. DOBBS, R.C. Effect of initial mass of white spruce and lodgepole pine planting stock on field performance in the British Columbia Interior.
Report, Pacific Forest Research Centre, Victoria, B.C., 1976, No. BC-X-149: 14 pp.
5 ref.
Subject Codes: 7.4, 7.4.3
RCA: X1147

This two-part report is directed to forest managers, as well as to others concerned with the practice of forestry and the forest environment. The first part, written in nontechnical language, covers all aspects of problems associated with the mountain pine beetle, including procedures and guidelines for coping with this insect, along with a selected reading list. Described in the second part are the biological interactions that occur when bark beetles attack trees. This section with its bibliography forms the basis for part one and can be referred to if satisfactory decisions cannot be made with the first part alone.

1076. ENDEAN, F. Conical container improves seedling growth on dry sites.
Tree Planters' Notes, 1973, 24(1): 26-29
3 ref.
Subject Codes: 7.4.3
CAB: 203355

Describes greenhouse and field trials in Alberta to compare the survival and growth of (a) 64- and 81-day-old planting stock of Pinus contorta var. latifolia raised in black polyethylene containers (3 1/2 inches high) consisting of a large truncated cone (base downwards) with a smaller truncated cone (base upwards) inserted into its upper end, and (b) 107-day-old P. c. var. latifolia stock raised in tubes. The conical containers were designed to aid root egress, and give increased rooting volume and improved moisture conservation. Results (after 11 weeks in the greenhouse, and after 2 years in the field) showed that the growth of (a) was considerably better than that of (b).

1077. ENDEAN, F., CARLSON, L.W. The effect of rooting volume on the early growth of lodgepole pine seedlings.
Canadian Journal of Forest Research, 1975, 5(1): 55-60
13 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.3
CAB: 451381

Lodgepole Pine (Pinus contorta var. latifolia) seedlings were germinated and grown for 20 weeks in containers with volumes ranging from 10 to 524 cm3 (0.6 to 32.0 in3). Containers for four of the seven volumes were made with three different height: diameter ratios (1:1, 3:1, and 6:1); for the remaining three volumes the ratio was 3:1. Rooting volume had a pronounced effect on dry weight and shoot length between 8 and 20 weeks. Rooting intensity was inversely correlated with dry weight of shoot and a restricting intensity of about 0.45 mg/cm3 is suggested. Configuration of the container had no effect on dry weight or shoot length.

1078. ENDEAN, F., HOCKING, D. Performance after planting of four types of container-grown lodgepole pine seedlings.
Canadian Journal of Forest Research, 1973, 3(2): 185-195
13 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.4.3
CAB: 226462

Describes a detailed study in Alberta in 1970-1971 in which 10- to 16-week-old seedlings of Pinus contorta var. latifolia, reared in the greenhouse under four different nutrient and irrigation regimes were transported into a controlled laboratory environment or into the field. After 12 weeks the seedlings were excavated and the stem length and dry weight of the shoots and roots were measured; data for these and derived parameters were compared with values found

at the time of planting. Survival was uniformly high; the seedlings that were largest before planting did best under all conditions. Results suggest that the largest plant that can be grown and planted economically shows the largest increment and achieves the greatest total dry weight and root dry weight in the first growing season after planting out. The need for physiological rather than morphological grading of seedlings is stressed.

1079. ETTER, H.M., CARLSON, L.W. Sugars, relative water content, and growth after planting of dormant lodgepole pine seedlings.
Canadian Journal of Plant Science, 1973, 53(2): 395-399
6 ref.
Language: en
Summary Languages: fr
Subject Codes: 3.3
CAB: 249372

Dormant 3-year-old seedlings of Pinus contorta var. latifolia were lifted from the field in Alberta and stored in air-tight plastic bags in the dark at 2 deg C for 3-4 months before planting in a greenhouse. The relative water content (RWC) of the needles, i.e. the water content as a % of the water content in a turgid state, and the sugar content of the roots were determined at planting time and 5 weeks later. Plants with actively growing root systems were those with a high sucrose content 5 weeks after planting; this difference was not evident at planting, and it is concluded that the sucrose was translocated from the shoots. Plants with a reduced capacity for root regeneration may have suffered damage to the photosynthetic or sugar-transport systems. New root growth was unrelated to the RWC at planting, but the RWC was 3-10% higher in the upper than in the lower needles.

1080. HARE, R.C. Effect of nine growth retardants applied to loblolly and slash pine
Cdn. Journal of Forest Research, 1982, 12(1): 112-114
9 ref.
Language: en
Summary Languages: fr
Subject Codes: 4.1
CAB: 1539686

In an attempt to dwarf seed orchard trees in south Mississippi without reducing seed production, 9 growth-retardant chemicals (dikegulac, daminozide, fosamine, chlorflurenol, EHPP, ethephon, mefluidide, NAA ester and paraquat) were applied at several concentrations as aqueous foliar sprays or oil-based bark bands. All treatments which significantly retarded growth also caused injury or death. Mefluidide, as a 0.7% foliar spray, reduced growth and caused only minimal injury. No control or treated trees flowered. Slash pine was more sensitive to the chemicals than loblolly pine.

1081. HOCKING, D. Copper toxicity in container seedlings grown in copper-bottomed flats.
Bi-monthly Research Notes, 1972, 28(4): 26
3 ref.
Subject Codes: 7.9
CAB: 098379

It has been the practice to spray with copper paint the trays in which containers are stood while rearing seedlings, in order to inhibit growth of roots outside the containers. A comparison of Pinus contorta var. latifolia seedlings grown in this way with controls from trays painted with non-copper paints, showed that the former were significantly he Cu content of their roots was about 10 times that of the controls. It is recommended that unwanted root growth should be controlled by routine root- pruning.

1082. HOCKING, D., COOK, F.D. Myxobacteria exert partial control of damping-off and root disease in container-grown tree seedlings.
Can. J. Microbiol., 1972, 18(10): 1557-1560
Subject Codes: 2.3
BIO: 55045677

1083. HOCKING, D., MITCHELL, D.L. The influences of rooting volume, seedling espacement and substratum density on greenhouse growth of lodgepole pine, white spruce, and Douglas-fir grown in extruded peat cylinders.
Canadian Journal of Forest Research, 1975, 5(3): 440-451
11 ref.

Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 546571

Seedlings of Picea glauca var. albertiana, Pinus contorta var. latifolia and Pseudotsuga menziesii were grown in closely packed extruded peat cylinders ('sausages') of different lengths, diameters and densities within a range found practical for use in the greenhouse. The highest peat density (0.23/cm3) was limiting to all growth parameters for all species at all the rooting volumes and cylinder spacings tested. At lower peat densities all growth parameters were linearly correlated with rooting volume. At the smaller rooting volumes and narrower spacings, growth restrictions were partially relieved by compression of the peat to a density of 0.2 g/cm3.

1084. LOW, A.J., OAKLEY, J.S. Tubed seedlings.
Leaflet, Forestry Commission, UK, 1975, No. 61: 17 pp.
8 ref.
Subject Codes: 7.4.2
CAB: 564556

A summary of Forestry Commission Bulletin No. 53 giving practical recommendations on raising and planting tubed seedlings of Pinus contorta and Picea sitchensis.

1085. MCCRACKEN, I.J. Packaging and cool storage of tree seedlings.
New Zealand Journal of Forestry, 1979, 24(2): 278-287
3 ref.
Subject Codes: N/A
CAB: 1299142

A general account of the methods and effects of cool storage covering preparation and packaging of material, types of cool store and length of storage. Max. recommended storage periods are: 20 weeks for birch, alder and larch; 3 weeks for Nothofagus and Eucalyptus; 18 weeks for Pinus mugo, P. contorta, P. ponderosa and P. sylvestris; 12 weeks for P. nigra and Douglas fir; and 6 weeks for P. radiata.

1086. MCCRACKEN, I.J., CATH, P.W. Production and handling of seedlings for high altitude planting. IN: Revegetation in the Rehabilitation of Mountain Lands.
FRI Symposium, New Zealand Forest Service, 1978, No. 16: 181-194
Subject Codes: N/A
CAB: 1203562

Seedlings of (a) Pinus mugo, (b) P. sylvestris and (c) P. contorta raised at Broken River (800 m alt.) grew better at high alt; than larger seedlings raised at low alt. Nursery procedures are described for (a), (b), (c), and (d) Alnus viridis, the importance of well- established mycorrhizal associations is stressed. Optimum planting stock size was 10- 15 cm for (a) and (d) and 25-30 cm for (b) and (c); root depth should be limited to 10-12 cm in all species by wrenching. Seedlings were lifted while still dormant and cool- stored in polythene-lined kraft-paper bags for planting in spring; cool-stored plants were under less water stress at planting and survived better than pit-stored plants.

1087. MELLOR, G.E. Nitrogen and conifer studies.
Dissertation Abstracts International, B, 1973, 34(2): 560-561
Subject Codes: 7.8
CAB: 399964

Describes the effect of N from different sources on growth of seedlings of Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla and Pinus contorta var. contorta. An additional study of the effects of mud-packing on seedlings is described in which two- year-old seedlings of P. menziesii were lifted in the spring, packed in mud and then stored under various conditions of light and temperature. Results showed that mud-packed seedlings stored in the field for 19 days and subsequently planted, survived best and had the greatest root growth. Treatment of the mud-packs with fertilizer and vermiculite had no effect on any of the variables measured.

1088. MITCHELL, D.L., HOCKING, D., KAY, W.C. Extruded peat cylinders: their physical characteristics as affecting tree seedling growth and greenhouse drought tolerance.
Canadian Journal of Forest Research, 1972, 2(4): 479-486
7 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 141302

Seedlings of Pinus contorta var. latifolia were grown in "sausages", i.e. containers formed by extruding a peat/water mixture into flexible plastic tubing which is then cut into short uniform cylinders. The reduction in peat particle size that occurs during extrusion improved the rate of moisture absorption and decreased the rate of moisture loss. The peat density in the sausages can be varied by controlling the water content in the feed mixture. Seedling growth decreases as peat density increases. Seedlings in sausages are less affected by drought than are seedlings in rigid tubes filled with loose peat.

1089. MITCHELL, D.L., HOCKING, D., KAY, W.C. Reforestation with tree seedlings grown in extruded peat cylinders: Part I - Mechanical aspects of the process.
Transactions of the American Society of Agricultural Engineers, 1972, 15(1): 36-39
15 ref.
Subject Codes: N/A
CAB: 059873

The process, in which a peat/water mixture is compressed in a rotating auger and the compressed material is extruded into a thin-walled, tubular plastic casing 1" in diameter and 15-20' long (subsequently cut into 3" sections) is described and illustrated. Experiments have shown that containers filled with a growth medium of uniform predetermined compaction are produced, and that controlled variation in container volume and growth-medium density is possible. Growth of Pinus contorta seedlings in containers thus made is equivalent or superior to growth in similar containers filled manually.

1090. MORBY, F.E., RYKER, R.A. Winter storage and packaging effects on Lucky Peak seedlings.
USDA For. Serv. Res. Note, Intermountain For. and Range Exp. Stn., 1975, No. INT-195: 10 pp.
3 ref.
Subject Codes: N/A
CAB: 556523

Seedlings (1 + 0 or 2 + 0) of Pinus ponderosa, Pinus contorta (var. latifolia), Pseudotsuga menziesii var. glauca, Picea engelmannii, Larix occidentalis and Purshia tridentata at the Lucky Peak nursery, Idaho, were lifted in Nov. and stored at 33 deg or 28 deg F in paper bags or in crates. Survival and growth at five planting sites were compared with those for similar planting stock lifted in Feb./Mar. Storage at 28 deg F reduced survival and growth for most species. The best packaging method and lifting season varied with the species but, in general, autumn lifting is thought to be feasible in the area studied.

1091. PELTON, N.R. The "Pelton mudpack": an alternate form of planting. IN: Root form of planted trees. Session D: Douglas-fir Region.
Ministry of Forests & Canadian Forest Service, 1978: 253-256
3 pl.
Subject Codes: 2.3, 7.4.2
CAB: 1146852

Lodgepole pine "mudpacked" planting stock (roots packed in a peat mixture) exhibited less root deformation than either bare-root stock or container-grown plugs. The mudpacked stock showed heavy lateral root development similar to that of naturally regenerated seedlings. It is suggested that growing of the stock in a controlled environment would provide even better results.

1092. ROSVALL-AHNEBRINK, G. Artificial hardening of spruce and pine seedlings in plastic greenhouses.
Translation, Environment Canada, 1980, No. 00ENV TR-1874: 10 pp.
Subject Codes: 6.4
CAB: 1514467

1093. SALT, G.A. Forest pathology: abnormal needle development in young lodgepole pine. IN: Report on Forest Research, Forestry Commission, UK. 1975: 59-60
1 ref. + 1 pl.
Subject Codes: 6.4
CAB: 604303

Reports studies of the effect of storage conditions on poor needle development in Pinus contorta. Polythene bags, each containing 100 transplants (1 + 1) of each of two provenances of sitka spruce, grand fir, and lodgepole pine, were stored at 2, 5 or 10 deg C from 14 Dec. 1973 until 2 April 1974. The transplants were planted at Wareham, Dorset, on the next day. Most plants survived harsh weather for a month after planting. Buds on P. contorta broke normally to produce a tuft of new green needles, but when shoots started to elongate, 'bottle-brush' abnormalities appeared on some plants. Among plants stored at 2, 5 and 10 deg., abnormal needle development was seen respectively on 65, 73 and 83% of plants in July and on 18, 19 and 33% in Dec. It is concluded that poor needle development is a physiological rather than a pathological phenomenon.

1094. SIMPSON, D.G. Production of container grown conifer seedlings in sewage sludge compost. E.P. 877.02. IN: Forest Research Review 1981-1982.
Ministry of Forests, Victoria, B.C., 1983: 24
Subject Codes: N/A
RCA: X1046

1095. TAHER, M.M., COOKE, R.C. Shade induced damping-off in conifer seedlings part 1. Effects of reduced light intensity on infection by necrotrophic fungi.
New Phytol., 1975, 75(3): 567-572
Subject Codes: N/A
BIO: 61033407

1096. THOMPSON, S., STAPLETON, C.M.A., STEVENSON, A.W. Growth of lodgepole pine seedlings raised under clear polythene cloches. IN: Pinus contorta as an Exotic Species.
Proc. of the 1980 IUFRO Working Party Meeting on Pinus contorta provenances (S2-02-06) in Norway and Sweden. Research Note No. 30, 1981: 155-165
15 ref.
Subject Codes: N/A
RCA: X1084

Cloche construction is described. Growth response of Pinus contorta Dougl. from seed through 24 weeks under cover are discussed.

1097. WANG, B. germination requirements and effect of seed weight on germination and early seedling development of Alberta lodgepole pine.
1979: 26 pp.
Subject Codes: N/A
RCA: X1030

## 7.4 PLANTING

1098. ADAMS, D.L. Germination trials of forest tree seed wafers.
Project IDA-ES-0113, Univ. of Idaho, Moscow, IDA, 01 July 75 to 31 Dec 76
Subject Codes: 7.4.4
CRIS: 0070006

Objectives: This project entails a study of a rapid and potentially inexpensive method of establishing tree regeneration on disturbed sites. Wafers composed of vermiculite, methyl cellulose, and activated carbon and containing tree seeds will be tested to evaluate germination characteristics. Approach: Three separate but related greenhouse studies will be undertaken to evaluate the germination potential, i.e., the time required for germination, and the total germination percentage, of waferized western white pine, ponderosa pine, lodgepole pine, Douglas-fir, grand fir and western larch seed. Comparisons will be made among the several species of waferized seed, between waferized seed and naked seed, and between different methods of planting wafers. Progress: This project entails a study of a rapid and potentially inexpensive method of establishing tree regeneration on disturbed sites. Wafers composed of a seed embedded in a tablet of vermiculite, methylcellulose, and activated carbon were tested to evaluate

germination characteristics. The project consists of three phases. Phase I was a greenhouse study which revealed that controls of untreated Douglas-fir and ponderosa pine seed had significantly higher germination values than waferized seed (Alpha = .05). Activated carbon significantly stimulated the germination of ponderosa pine seed wafers but had no significant effect on white pine or Douglas-fir seed wafers. Phase II was on extensive field planting in which percent germination was extremely low. Mortality has been attributed to severe spring and summer drought conditions, cattle trampling, and rodent depredation. Phase III consisted of two greenhouse studies designed to determine the effects wafers have on imbibition and gas exchange. Wafers significantly increased the imbibition rate of Douglas-fir seed over untreated controls. No significant differences were found between wafers and controls of ponderosa and white pine seed. In the second study CO(2) evolution by seeds is currently being measured using gas Chromatographic techniques.

1099. CHATTERTON, C.E., RYKER, R.A. Effects of different tree packages vary with species and habitat type.
USDA For. Ser. Res. Note, Intermountain For. & Range Experiment Stn., 1976, No. INT-214: 6 pp.
4 ref.
Subject Codes: 5.1, 7.3
CAB: 1044910

Seedlings (2+0) of Pinus contorta and P. ponderosa were lifted in an Idaho nursery in April 1972, packed with moist sphagnum moss in (a) polythene-lined kraft paper bags, (b) polythene bags inside fibreboard boxes, or (c) open-ended wooden crates, and planted in May/June 1972 at two clear-felled sites in the Boise National forest, Idaho: a P. contorta site with low temp. (12.2-17.8 deg. C) and high RH (34-51%) at planting, and a Douglas-fir site with temp. (23.3-26.7 deg. C) and low RH (18-34%). Height growth and 3- year survival of P. contorta were greatest in (c) and least in (b) stock. Height growth and survival of P. ponderosa were least in (c). Survival of P. contorta was less than that of P. ponderosa at both sites. Growth of both spp. was best in the cooler site and P. contorta grew better than P. ponderosa on both sites. Packaging (c) is recommended for P. contorta and (a) for P. ponderosa, or either type under optimum conditions.

1100. JAWORSKI, A., MAJERCZYK, K. Assessment of the commercial value of the more important exotic tree species in the Krynica forests (near Krakow, Poland).
Sylwan, 1975, 119(11): 41-56
27 ref.
Language: pl
Summary Languages: ru, en
Subject Codes: N/A
CAB: 653247

Tabulates and discusses data on the increment and stem quality of 15 trial plots, 31-70 years old, of Abies grandis, Pinus contorta var. latifolia, P. strobus, Pseudotsuga menziesii and Thuja plicata on deciduous or mixed-forest sites at 650-750 m alt. All the species were as good as or better than larch and other native species on the same sites, although Pinus contorta was very susceptible to damage by wind and congealed snow. A. grandis (40 years old) was outstanding, followed by Pseudotsuga menziesii. The results encourage trials of exotics on a larger scale in mountain districts of Poland.

1101. KOHMANN, K. Plant "plug-plants" deep enough]
Norsk Skogbruk, 1979, 25(5): 3-5
12 ref., 2 pl.
Language: no
Summary Languages:
Subject Codes: 7.3
CAB: 1071452

A study of the effect of type of planting stock, depth of planting and other factors on stability and root deformation of Picea abies, Pinus sylvestris and P. contorta with special reference to plants raised by the Kopparfors (multiple container) method. In a trial with 2-year P. abies, plants in which the top of the root ball was placed 2-3 cm below the surface produced better height and root growth, including adventitious roots from the buried stem, than flush planting. Results were similar for P. sylvestris. In P. contorta, shallow planting caused instability and crooked stems. Deep planting produced straight stems and longer terminals. To improve stability, each individual container will in future be equipped with 6 vertical guiding ridges to prevent spiral root growth.

1102. LINES, R. The development of forestry in Scotland in relation to the use of Pinus contorta. IN: Pinus contorta provenance studies.
Res. & Dev. Paper, Forestry Commission, UK, 1976, No. 114: 2-5
2 ref.
Subject Codes: 8.1, 8.8
CAB: 1118595

1103. LOW, A.J. Production and use of tubed seedlings.
Forestry Commission Bulletin, UK, 1975, No. 53: vii + 46 pp.
30 ref. + 20 pl.
Subject Codes: 7.3, 7.4.3
CAB: 536415

Reports in detail the results of an extensive research and development programme of the UK Forestry Commission from 1968 to 1973 on the production and use of tubed seedlings of Pinus contorta and Picea sitchensis. Results from many nursery and forest experiments are described. Seedlings grown in small plastic tubes of fertilized peat/sand mixture in heated polythene greenhouses are normally ready for planting eight weeks after sowing. High rates of planting (up to 740 seedlings per hour) are possible with a special tool (described) on peat ridges already stepped by hand, and planting can be done from mid April to late August. Results have been satisfactory on ploughed peatland, but unstaisfactory (severe frost-heaving and poor height growth) on ploughed mineral soil and on felled areas on mineral soils. Practical recommendations are made on raising and planting tubed seedlings.

1104. NILSEN, S. Seedlings of Norway spruce, Scots pine, and lodgepole pine grown in rockwool.
Meddelelser fra Norsk Institutt for Skogforskning, 1977, 33(5): 229-252
1 pl.
Language: en
Summary Languages: no
Subject Codes: N/A
CAB: 1146702

A technique was tested for growing seedlings for experimental purposes using rockwool as growing medium in plastic multipot trays; irrigation once a day with a nutrient containing 100 mg/litre N was optimal. Because Ca and Mg were released from the rockwool it was concluded that the technique was suitable for experiments where the environment (light, temp., humidity) is defined but not where defined nutrition is required.

1105. SHEPPERD, W.D., NOBLE, D.L. Germination, survival and growth of lodgepole pine' under simulated precipitation regimes: a greenhouse study.
USDA For. Serv. Res. Note, Rocky Mountain For. and Range Exp. Stn., 1976, No. RM-328: 4 pp.
5 ref.
Subject Codes: 7.3
CAB: 796116

The effect of the amount and timing of watering on Pinus contorta seedlings was observed for 22 weeks in 1973. Germination and overall growth increased directly with the amount, but not frequency of distribution, of water given (up to 2 inches/month) whereas survival was dependent upon both factors.

1106. WALKER, N.R. Field performance of Spencer-Lemaire container seedlings in west-central Alberta.
Info. Rep., Northern For. Res. Centre, Canada, 1978, No. NOR-X-207: 14 pp.
9 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: 5.1, 5.2
CAB: 1369013

Sample plots planted to Pinus contorta var. latifolia and Picea glauca were established in 1972, 1973 and 1974; 1st and 3rd year percentage survival, average height, percentage heaving, and average DM were measured (these were also measured

at 5 years for 1972 planting). Overall 3rd year survival was 80% or better for 68% of plots. Growth was slower than expected: specific site and competition factors are discussed which may have affected growth and survival. It is recommended that the greenhouse rearing period be extended from 4 to 10 weeks.

1107. WALKER, N.R., BALL, W.J. Larger cavity size and longer rearing time improve container seedling field performance (of white spruce, lodgepole pine and jack pine in Alberta and Saskatchewan).
For. Management Note, Northern For. Res. Centre, Canada, 1981, No. 6: 2 pp.
Subject Codes: 7.3
CAB: 1499763

7.4.1 PLANTATION ESTABLISHMENT

1108. FENTON, R. Risks or the case for diversification of production plantation species and the role of Douglas-fir.
N.Z. For. Serv., For. Res. Inst., FRI Symp. (15), 1978: 433-446
Subject Codes: N/A
BIO: 16022455

1109. GOMIS, H.D. Establishment of a plantation of Pinus contorta var. latifolia in the southern cordillera of Rio Negro, Argentina.
Revista Forestal Argentina, 1973, 17(4): 107-108
Language: es
Summary Languages:
Subject Codes: 7.4.3
CAB: 249328

Describes a plantation established in 1968 with 1 + 2 stock at a spacing of 2 x 2 m, on a degraded, over-grazed, scrub-invaded site, and gives details of increment up to 1973. The pine has grown well, height increment in 1973 being ca. 1 m and total height 2.5- 3.5 m. though some forking is evident.

1110. KARPACHEVSKII, L.O., BUDANTSEV, P.B., ALEKSANDROVICH, V.E. The use of informational logical analysis for the evaluation of the effect of soil and climatic factors on the productivity of forest plantations from introduced and aboriginal arboreal types.
Pochvovedenie (7), 1978: 126-136
Language: ru
Summary Languages:
Subject Codes: 3.0
BIO: 68021793

Productivity of several arboreal species (Scotch pine, Weymouth pine, lodgepole pine, Norway spruce, fir, oak) introduced in the European USSR (within the boundaries of Baltic Sea Area, Orlovsky region, Saratovsky region) is closely related with soil and climatic factors (humus reserves in the A + B horizon, humus content in the Al horizon, the degree of base saturation, the clay content in the Al horizon, the quantity of summer precipitation, and the length of growing period). Formulae are given for the prediction of forest plantation productivity according to ecological factors.

1111. MIGLIOLI, J.A., ROZADOS, J.J. The growth of exotic conifers in the Cordillera region of the northwest of the Province of Chubut, Argentina. IN: Proceedings of the Seventh World Forestry Congress, 4-18 October, 1972.
Buenos Aires, Argentina, 1978: 1665-1669
Language: es
Summary Languages: en, fr
Subject Codes: N/A
CAB: 1191071

1112. SILLERSTROM, E. Go easy with Pinus contorta.
Skogen, 1976, 63(13): 536-537
Language: sv

Summary Languages:
Subject Codes: 5.0, 8.1
CAB: 746848

Caution is urged in extending P. contorta as a plantation species in Sweden on the grounds that too little is known about it at ages greater than 50 years. Available increment data suggest that over long periods it is not notably high-yielding as compared with P. sylvestris. It is recommended only for very high or exposed sites.

7.4.2 METHODS

1113. HOLSTENER-JOERGERSEN, H., HOLMSGAARD, E. Fertilization and irrigation of young Norway spruce on sandy soil.
Forstlige Forsoegsvaesen i Danmark, 1975, 34(3): 263-270
4 ref.
Language: en
Summary Languages: da
Subject Codes: N/A
CAB: 564586

Describes a trial in which plots in a poor heathland plantation of Norway spruce, planted in alternate rows with Pinus contorta as a nurse tree in 1960 at Gludsted, Denmark, were treated in 1971 with NPK fertilizer and/or irrigated to give a roughly optimum moisture supply. Smaller repeat dosages of fertilizer were applied in 1972 and 1973. Height growth reacted to fertilizer as early as the year of application. In the second year, the fertilizer effect was nearly doubled, and there was a small response to irrigation. In the third year, the response to irrigation exceeded that to fertilizing, and combined irrigation and fertilizing produced a height increment more than 3 times that on control plots and comparable with the height increment of spruce of site class 1.

1114. O'CARROLL, N. The nursing of Sitka spruce (Picea sitchensis). 1. Japanese larch (Larix leptolepis).
Irish Forestry, 1978, 35(1): 60-65
2 ref., 2 pl.
Subject Codes: N/A
CAB: 1118679

In an experiment in Co. Cork, Ireland, begun in 1960, both Larix leptolepis and Pinus contorta were used as nurses for Sitka spruce, in intimate mixture (equivalent to mixture by single lines, diagonally) or in bands of 2 lines each. The site was dominated by Molinia caerulea and Calluna vulgaris. NPK fertilizer was applied in 1967. There were no significant differences between treatments or as compared with pure spruce, for the first 10 years. In the next 6 years the larch had a significant effect on the height growth of the spruce, and at 18 years the pine also began to show an effect. It is suggested that the effect of the deciduous larch is to mobilize reserves of N. In 1978 (?) pure spruce plots had an annual height increment of about 10 cm - those with pine 15 cm and those with larch 35 cm.

1115. THOMPSON, S., BIGGIN, P. The use of clear polythene cloches to improve the growth of one-year-old lodgepole pine seedlings.
Forestry, 1980, 53(1): 51-63
23 ref.
Subject Codes: 4.2, 7.3
CAB: 1233158

Unsterilized nursery beds near Elgin, Scotland, were prepared in the normal way (including herbicide treatment), sown and covered with cloches with or without buried edges for 0-21 wk. All cloche treatments increased germination; survival was greatest in the sealed cloches (98% of germinated seedlines at 8 wk old). Seedlings covered for 16-21 wk were 3 times the ht. of controls, but not sturdy enough for forest use. A scheme is described for raising 1+0 seedlings for lining-out or possible forest planting.

## 7.4.3 SPECIES TRIALS

1116. AHLBACK, A. The westernmost outposts of Scandinavian forestry (a study tour to the Faroe Islands, Greenland and Iceland).
Skogsagaren, 1974, 50(5): 23-30
Language: sv
Summary Languages:
Subject Codes: N/A
CAB: 296604

Briefly discusses natural tree growth (if any), planting activities, existing plantations, costs, suitable species (e.g. conifers, Populus trichocarpa var. hastata and Alnus sinuata), policies, etc. In the Faroes, plantations are established as much for recreation as for timber production. Pinus contorta appears to be the most successful species to establish, but tends to sicken and die at about 40 years old. In Greenland, in afforestation trials established from 1959 onwards with planting stock raised locally (imported stock having failed), the older plants have reached heights up to 3 m. At Tasermiut, at about the same latitude as Uppsala, Larix sibirica was the most successful species, followed by Picea abies and P. lutzii (P. sitchensis X P. glauca); at Kanagssiagsat, ca. 120 km further north, Pinus sylvestris was second best. It is regretted that the discontinuance of the nursery for financial reasons endangers the extension of a promising afforestation venture.

1117. BAER, N.W., RONCO, F., BARNEY, C.W. Effects of watering, shading and size of stock on survival of planted lodgepole pine.
Research Note, Rocky Mountain For. & Range Experiment Stn., USDA Forest Service, 1977, No. RM-347: 4 pp.
9 ref.
Subject Codes: 7.3
CAB: 1442533

Study plots were established in 1973 (a wet year) and in 1974 (a dry year) in two areas in the Bighorn National Forest, Colorado. Seedlings (2+0) of two size classes (above and below average) were treated by shading during the first growing season and by watering (1973 only), or not treated. Survival was measured for 1-3 growing seasons. Results showed that plantations established in dry years suffered greater losses from water stress and that shading reduced losses significantly. Below average size seedlings survived better than larger seedlings when established in a dry year.

1118. BIROT, Y., SZIKLAI, O. (Chairman) Field experiments and performance of species: Douglas-fir provenances. IN: Proceedings of the IUFRO Working Party Mtg. - Vancouver, 1978.
Victoria, B.C., Canada, Ministry of Forests Info. Serv. Branch, 1980: 169-426
Language: en, de
Summary Languages: en, de
Subject Codes: N/A
CAB: 1358129

Twenty papers on: forest hardiness (Larsen, J.B.); height growth and forest resistance in W. German trials (Reck, S.G.); photoperiodism - including Scots pine (Wiersma, J.H.); a data banking system (Birot, Y.); topoclinal variation (Campbell, R.K.); and trials in: Australia (Griffin, A.R., Matheson, A.C.); Pacific Northwest (Ching, K.K., Hinz, P.); Netherlands (Kriek, W.); Norway (Magnesen); Ireland (O'Driscoll, J.); Scotland (Lines, R.); W. Germany (Weisgerber, H. and Kleinschmit, J.); Belgium - including Abies grandis and Sitka spruce (Nanson, A.); Italy (Vecchi, E.); Turkey (Simsek, Y.); Estonia - including lodgepole pine, Sitka spruce and fir (Etvergk, I.); England and Wales (Pearce, M.L.); Czechoslovakia (Zavadil, Z., Sika, A.); and British Columbia (Illingworth, K.).

1119. BIRYUKOV, V.I., MAZUR, V.A. Plantations of Pinus contorta in the central forest-steppe.
Lesnoi Zhurnal, 1975, No. 3: 11-12
3 ref.
Language: ru
Summary Languages:

Subject Codes: N/A
CAB: 564536

Describes investigations on leached chernozem and on podzolized clay-loam in the Lipetsk and Orel regions, USSR, of the performance of P. contorta in several small plantations up to 43 years old. On soils with adequate moisture, P. contorta outgrows P. sylvestris up to 20 years of age, but on dry soils it is decidedly inferior to P. sylvestris. P. contorta starts fruiting at 12 years, and natural regeneration is abundant. It is not affected by droughts or low temperatures. The wood is superior to that of P. sylvestris though inferior to that of Larix sibirica grown in the same conditions. P. contorta is recommended for use in the central forest-steppe zone; it is suitable for amenity planting and protective stands on gulley slopes with moist and fairly moist soils.

1120. CHRISTENSEN, S.A. Tree species from Australia and Argentina for the Faroe Islands. The Faroe plantations in 1975.
Hedeselskabets Tidsskrift, 1975, 96(9): 184-187
Language: da
Summary Languages:
Subject Codes: 1.4
CAB: 536353

Briefly describes the development and extension of tree plantations on the islands, choice of species and provenances etc., on the basis of a recent visit. Pinus contorta and P. mugo of French origin are now the chief species planted. Populus trichocarpa var. hastata (from Alaska) and Alnus sinuata have developed very satisfactorily. A number of Eucalyptus species from Tasmania and New South Wales, and two Nothofagus species from Argentina (N. pumilio and N. alpina), were planted in 1975.

1121. CLARK, M.B. Operational planting trials. E.P. 790.01. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 39
Subject Codes: N/A
RCA: X1051

1122. COZZO, D. Further information on the growth in Argentina of Pinus contorta var. latifolia, P. ponderosa and P. radiata near the S. of the humid region of Patagonia.
Revista Forestal Argentina, 1972, 16(2): 43-46
1 ref.
Language: es
Summary Languages:
Subject Codes: N/A
CAB: 059834

Gives growth data for the three Pines in experimental plantations (20-22 years old) at Trevelin (province of Chubut) 25 km SW of Escuel (lat. 43 deg., 5' S., long. 71 deg. 30'W) at 450- 480 m alt. on the slopes of the Andes. The general trends were similar to those of more northerly plantations. P. contorta var. latifolia had the lowest m.a.i. but is the most tolerant of wide variations in soil and climate; P. radiata made the quickest growth; and P. ponderosa was intermediate. P. contorta var. latifolia showed abundant, and P. ponderosa moderately good, natural regeneration.

1123. CUNNINGHAM, A. Species trials for erosion control in the Kaweka Range. IN: Revegetation in the Rehabilitation of Mountain Lands.
FRI Symposium, New Zealand Forest Service, 1978, No. 16: 139-152
Subject Codes: 8.8
CAB: 1203558

A report of trials started in 1959 to halt erosion at 1000-1600 m alt. around Makahu Saddle (Hawke's Bay). Pines were superior to all other genera throughout the alt. range; at 1400 m and above, Pinus mugo ssp. mugo grew better at 10 yr old than P. contorta. Native species showed poor survival and growth, except for Salix spp. where moisture was adequate and Hebe venustula which grew well on loose scree.

1124. CUNNINGHAM, A., ROBERTS, Q. A provenance trial of Pinus-contorta at 4800 feet in the Kaweka range - assessment after 7 years.
New Zealand J. Forest., 1970, 15(1): 79-87

Subject Codes: 1.4
BIO: 52048633

1125. EDMONDS, T.W. Experimental shelterbelt in Otago.
Farm Forestry, 1975, 16(4): 92-97
Subject Codes: 8.8
CAB: 585034

Describes an experimental shelterbelt composed on trees of 24 coniferous and deciduous species planted in 1965 and 1966. The merits of the different species are discussed and the importance of first establishing really hardy species in the harsh climate of Otago, New Zealand, is stressed. Inspections in 1966, 1967, 1968 and 1972 showed that Pinus contorta is the most successful species, but after 9 years it shows signs of instability.

1126. ETTER, H.M. Growth metabolic components and drought survival of lodgepole pine seedlings at 3 nitrate levels.
Can. J. Plant Science, 1969, 49(4): 393-402
Subject Codes: 3.3, 6.4
BIO: 51005149

1127. GISLERUD, O. Foreign coniferous tree species in mountain forests in Eastern Norway: wood properties and possibilities for industrial use. A literature study.
Tidsskrift for Skogbruk, 1974, 82(2): 213-230
45 ref.
Language: no
Summary Languages: en
Subject Codes: 8.1
CAB: 304885

Reviews the literature on the suitability of Abies lasiocarpa, Larix sibirica, Picea engelmannii and Pinus contorta as crop species in relation to the climate of E. Norway and the timber and pulping characteristics required by local mills.

1128. HAGNER, S., FAHLROTH, S. The prospects of growing Pinus contorta in North Sweden
Sveriges Skogsvardsforbunds Tidskrift, 1974, 72(4): 477-528
3 ref.
Language: sv
Summary Languages: en
Subject Codes: 1.4
CAB: 409302

Seeds of Pinus contorta from 27 provenances throughout the entire northern range of the species in N. America (latitudes 48-63 deg N) were subjected to a hardiness test (of one-year-old seedlings) and 14 of the provenances were selected to establish trials at six sites in N. Sweden. Results after 5 years are reported. At the most northerly sites, the most northerly provenances survived best and, at all the sites, survival of the best provenances was at least as good as that of P. sylvestris. Most provenances showed mean heights and mean height increments in the fifth year that were superior to those of P. sylvestris. Two measures of hardiness (the pattern of shoot growth during the growing season and the dry-matter content of needles in the autumn) suggest that northern provenances have a growth cycle well suited to N. Sweden. Experimental plantations established in 1970-1972 have shown good survival but also some serious rodent damage.

1129. HALL, J.P. Survival and growth of exotic Pinus species in central Newfoundland and ten years after planting.
Info. Rep., Newfoundland For. Res. Centre, Canada, 1977, No. N-X-154: 12 pp.
7 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1202918

In 1966, Pinus sylvestris, P. contorta, P. banksiana, P. resinosa, P. cembra,

P. albicaulis and P. nigra var. corsicana were planted in a randomized complete-block design in east- central Newfoundland, on a site which had been clearcut and then burned. After 10 yr, survival and ht. increment showed that P. banksiana, P. contorta and P. sylvestris are suitable for reforestation; results from P. resinosa were inconclusive.

1130. HOLMSGAARD, E., BANG, C. A species trial with conifers, beech (Fagus sylvatica) and oak (Quercus robur). The first ten years.
Det Forstlige Forsoegsvaesen 1 Danmark, 1977, 35(2): 159-196
3 ref.
Language: da
Summary Languages: en
Subject Codes: 8.5
CAB: 984130

The conifers were Abies alba, A. grandis, A. procera, Larix leptolepis, Picea abies, P. sitchensis, Pinus contorta, P. mugo rostrata (P. uncinata), Pseudotsuga menziesii and Chamaecyparis lawsoniana. The trial was started in 1964/1965 on 13 trial areas and evaluated in spring 1975 as to number of plants per ha and mean plant height. Establishment and maintenance costs are shown, and for three blocks established under canopy, data on the proceding stand are given, as well as gross and net proceeds from its removal.

1131. O'DRISCOLL, J. The importance of lodgepole pine in Irish forestry.
Irish Forestry, 1980, 37(1): 7-22
28 ref.
Subject Codes: 1.4
CAB: 1358137

An historical account of the introduction and planting of lodgepole pine in Ireland followed by reports of a series of provenance trials made since 1962. Best results have consistently been obtained with (a) S. coastal (U.S.A.) provenances var. contorta with an average yield class of 16 (m3/ha m.a.i.) compared with 10 for (b) N. coastal (Canadian) var. contorta and 6 for (c) inland provenances of var. latifolia and murrayana. The occurrence of basal sweep was found to be greater in (a) than in (b) or (c). However, it is suggested that the faster growth and easier establishment of (a) outweighs the loss of quality through sweep.

1132. POLLACK, J. Tree species trial in the Kitimat valley. E.P. 712. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 37 pp.
Subject Codes: N/A
RCA: X1050

1133. POURTET, J. The Ministry of Agriculture's arboreta, and some of their lessons for forestry.
Revue Forestiere Francaise, 1979, 31(4): 275-285
4 pl.
Language: fr
Summary Languages: en, de, es
Subject Codes: N/A
CAB: 1146940

The growth and development of various species in French arboreta is reported on. The short lifespan of western American firs, the susceptibility to dry conditions of Japanese species and the disappointing results obtained with Pinus murrayana, P. contorta (lodgepole pine) and Prunus serotina are noted. Douglas-fir, Pinus muricata, P. peuce, P. heldreichii, Picea omorika and Calocedrus decurrens (Libocedrus decurrens) have been successful. Two N. American broadleaves have been particularly successful: black walnut and red oak (Quercus rubra). The latter was naturally regenerated in 1924-28 to form a stand at Les Barres.

1134. REHFELDT, G.E., LOTAN, J.E. Pinus-contorta x Pinus-banksiana hybrids tested in northern Rocky Mountains.
US Forest Serv. Research Note INT-126, 1970: 1-7
Subject Codes: N/A
BIO: 71031852

1135. REMROD, J. Lodgepole pine in Sweden.
Kungl. Skogs-och Lantbruksakademiens Tidskrift, 1977, 116(3): 119-149
Language: sv
Summary Languages: en
Subject Codes: 3.7, 5.1, 5.5
CAB: 806307

A further assessment of yield data from experimental plantations, 30-50 years old. Compared with Pinus sylvestris plantations on similar sites, P. contorta plantations are considered to improve the site quality (especially on poor sites), produce 25-30% more wood (10-25% when compared with improved P. sylvestris from seed orchards) and have an optimum rotation 15-20 years shorter. Wood quality, however, was poorer and plantations were subject to greater risk from snowbreak and windthrow. It is thought likely that P. contorta of suitable provenances would increase wood production in northern and central Sweden; in southern Sweden, where injuries from pests and diseases were greater, Picea abies is recommended. A 17-page group discussion is included.

1136. RICHARDSON, J. Survival and early growth of plantations on a drained fen in central Newfoundland.
Info. Rep., Newfoundland Forest Research Centre, 1979, No. N-X-178: 4 + 21 pp.
12 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1472343

The fen was drained using drainage-furrow spacing of 2 or 4 m; plantations were established in 1973 using planting stock (various age classes) of (a) Picea mariana, (b) Pinus contorta var. latifolia, (c) Picea glauca, (d) P. sitchensis, and (c) Betula papyrifera; results up to 1977 are presented. In a spacing trial (1.2, 1.8 and 2.4 m) involving (a) and (b), survival and ht. growth among spacings were n.s.d. Average survival rate was: (a) 81.2%, (b) 52.6%, (c) 73.8%, (d) 86.6%, (e) 16.0%. Average total height (cm) was: (a) 30.4, (b) 63.6, (c) 17.0, (d) 21.9, (e) 33.2. Survival and ht. growth were better on furrows spaced 2 m apart.

1137. THOMPSON, C.F. Plantation performance assessment in the Nelson forest region. E.P. 802. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 40
Subject Codes:
RCA: X1052

1138. VYSE, A. Field performance of small volume container seedlings. E.P. 859.07.
IN: Forest Reseach Review, 1981-82
Ministry of Forests, Victoria, B.C., 1983: 41
Subject Codes: N/A
RCA: X1054

1139. WALKER, N.R., JOHNSON, H.J. Containerized conifer seedling field performance in Alberta and the Northwest Territories.
Information Report, Northern For. Res. Centre, 1980, No. NOR-X-218: iv + 32 pp.
15 ref., 4 pl.
Language: en
Summary Languages: fr
Subject Codes: 7.1, 7.3
CAB: 1526944

Trials were carried out at 5 sites in Alberta and one in the Northwest Territories, using seedlings of lodgepole pine, Engelmann spruce, white spruce and jack pine. Seedlings were reared in 2 types of 40 cm3 peat plugs: the BC/CFS styroblock and the ARC "sausage", and were planted out with bare- rooted controls between 1971 and 1974. Three and 5-year results showed that container-grown seedlings survived better, grew well, and could be planted out after June, unlike bare-rooted seeldings. Styroblocks produced larger seedlings in 3 of the 4 years and were easier to rear.

## 7.4.4 RECLAMATION AND REVEGETATION

1140. BJARNASAON, H. Erosion, tree growth and land regeneration in Iceland. IN: The Breakdown and Restoration of Ecosystems.
New York, U.S.A., Plenum Press, 1978: 241-248
1 ref.
Subject Codes: 8.8
CAB: 1203340

A brief section on forest plantings (first made in 1900) includes as productive species: Siberian larch (Larix sibirica) of an Archangel provenance, Sitka spruce, and lodgepole pine.

1141. BROAD, K.F., ZEHETMAYR, J.W.L. Tree planting on man-made sites in Wales.
Edinburgh, UK; Forestry Commission, 1979: 50 pp.
12 ref., 4 pl.
Subject Codes: N/A
CAB: 1487640

After a brief historical introduction to the Forestry Commission's work in planting trees on derelict land in Wales over the last 30 years, the use of yield class to assess the success of planting schemes is described. Detailed experimental methods and results are given for planting projects on opencast coal-mining sites, colliery spoil heaps and degraded soils. Brief descriptions are also given for projects on derelict wastelands (the lower Swansea valley, industrial tree screens, quarries) and roadside planting schemes. The species most commonly used were Pinus sylvestris, P. nigra, P. contorta, Larix leptolepis, Picea sitchensis, Fagus sylvatica, Acer pseudoplatanus, Fraxinus excelsior and Betula alba.

1142. CONDON, L, O'CARROLL, N. Notes on afforestation of open-cast mining site at Rossmore Forest (Co. Carlow.).
Irish Forestry, 1975, 32(2): 115-117
Subject Codes: N/A
CAB: 619181

Presents a brief progress report after two growing seasons of planting trials with Abies grandis, Pinus contorta, Alnus glutinosa, Larix leptolepis, Acer pseudoplatanus, Picea sitchensis and Pseudotsuga menziesii on spoil heaps from coal-mining operations. Best survival and health were shown by alder, larch and pine.

1143. COOK, C.W. Surface mine rehabilitation in the American west.
Environ. Conserv., 1976, 3(3): 179-183
Subject Codes: N/A
BIO: 77015514

1144. FAULKNER, M.E., TROTMAN, I.G., GARNETT, B.T. Aerial seeding of pines for protection afforestation: Kaweka Forest, Hawke's Bay.
New Zealand Journal of Forestry, 1972, 17(1): 81-90
4 ref.
Subject Codes: N/A
CAB: 067817

Reviews trials started in 1965 on the aerial sowing of Pines (mainly Pinus contorta) to revegetate erosion areas. Results indicate that after 5 years the stocking is satisfactory (620-740 seedlings/ha) at altitudes up to 1200 m, but at higher altitudes supplementary planting may be necessary. Various factors affecting survival are discussed.

1145. FERDA, J., MOTTL, J., PRUDIC, Z. Growth of some introduced conifers along the ridge of the Ore Mountains Czechoslovakia.
Lesnictvi (Prague), 1982, 28(2): 123-138
Language: cs
Summary Languages:
Subject Codes: 6.5, 7.4.1
BIO: 75002731

Problems of afforesting extracted peat moors on the ridge plateaux of the Ore Mts. were examined by growth analyses of 50-yr-old trees of European larch (Larix

decidua (Pinea glauca Voss) and 70-yr-old white pine (Pinus strobus L.) conserved on the test area. Mound planting of mature plants should be performed to afforest these localities and protective birch stands should be planted. Introductions of the following conifers is recommended: white spruce, black spruce (P. mariana B.S.P.), Colorado spruce (P. pungens latifolia S. Wats.), white pine, stone pine (P. cembra L.) and other pines. In the experimental area where most conifers were damaged by emissions, European mountain ash, European aspen and especially pubescent birch were conserved.

1146. GROSSNICKLE, S.C., REID, C.P.P. The use of ectomycorrhizal conifer seedlings in the revegetation of a high-elevation mine site.
Can. J. For. Res., 1982, 12(2): 354-361
Language: en
Summary Languages: fr
Subject Codes: 2.3, 7.4.3
LISC: 698783

Three conifer species: Pinus contorta Dougl., Pinus flexilis James, and Picea engelmannii Parry, were inoculated with the ecotmycorrhizal fungi Pisolithus tinctorius (Pers.) Coker & Couch, Suillus granulatus (L. ex Fr.) Kuntze, and Cenococcum geophilum Fr. These, plus noninoculated control seedlings, were grown in a greenhouse for 8 months to assess mycorrhizal formation and seedling reponse. For all conifer species, top height, diameter, and seedling total dry weight were greater in the S. granulatus and control ("wild" fungus) treatments as compared with P. tinctorius and C. geophilum. In the 2nd year of the study, greenhouse container-grown conifers with ectomycorrhizae formed by the above three fungi and an unknown fungus were planted under four fertilizer treatments on a high-elevation (3 200 m) molybdenum tailing pond covered with deep mine waste rock. After 4 years in the field, height growth of the seedlings (all tree species combined) inoculated with S. granulatus was greater than seedlings inoculated with P. tinctorius, C. geophilum or control ("wild" fungus). Through four growing seasons, a sewage sludge and wood-chip treatment resulted in greater height growth than the three treatments of combined inorganic N and P, P alone, and no fertilization. The combined survival for all species and all treatments was 58% after four growing seasons.

1147. KOSMER, H.J. Colonization of the Discovery Bay sand dunes.
Forestry Tech. Papers, Forests Commission, Victoria, 1975, No. 22: 29-34
Subject Codes: 7.4.3
CAB: 604106

Describes a pilot study established in 1964 at Discovery Bay, Victoria, to determine the suitability of 42 species, including trees (deciduous and coniferous) and shrubs, for sand dune stabilization and possible commercial purposes. Plots were located so as to represent the four distinct seres present in the natural vegetation. Final results in 1972 showed that 22 species survived well when protected from browsing animals, though only 6 species (Leptospermum, laevigatum, Acacia cyanophylla, Casuarina stricta, C. sophorae) were considered to show satisfactory survival and height growth. None of the species planted could be recommended for commercial purposes, though further trials of P. contorta with fertilizer applications to improve growth are suggested.

1148. SCHWENDIMAN, J.L. Coastal sand dune stabilization in the Pacific Northwest.
International Journal of Biometeorology, 1977, 21(3): 281-289
16 ref.
Subject Codes: 8.8
CAB: 939876

An account of the sequence of sand dune stabilization by planting in the following stages: (a) establishment of sand-stilling grasses; (b) establishment of secondary permanent grasses and legumes; (c) establishment of woody plants e.g. Salix hookeriana and Pinus contorta.

1149. STRIFFLER, W.D., MOGREN, E.W. Erosion soil properties and revegetation following a severe burn in the Colorado Rockies. IN: Fire in the Northern Environment, Symposium. VII+275P.
Pacific NW For. and Range Exp. Stn., Portland, Oregon, 1971: 25-36
Subject Codes: 6.3
BIO: 72058163

## 7.5 CUTTING METHODS

1150. ALEXANDER, R.R. Partial cutting practices in old-growth lodgepole pine. USDA For. Sory, Research paper, Rocky Mountain For. and Range Exp. Stn., 1972, No. RM-92: 16 pp.
35 ref.
Subject Codes: N/A
CAB: 091210

Gives guidelines for the management of Pinus contorta in the central Rocky Mountains by modified shelterwood or group-selection fellings, to maintain forest cover in areas important for water yield, wildlife habitat, recreation and scenic beauty, as well as for timber production. Stand conditions, windfall risk, and insect and disease susceptibility are considered. Where timber production is the primary object, clear felling in small, dispersed units is recommended.

1151. ALEXANDER, R.R. Partial cutting in old-growth lodgepole pine. USDA For. Serv. Res. Paper, Rocky Mountain For. and Range Exp. Stn., 1975, No. RM-136: 17 pp.
38 ref.
Subject Codes: 3.2
CAB: 502939

Guidelines are given for the conversion of old-growth stands of Pinus contorta in the Rocky Mountains to managed stands while maintaining continuous forest cover in areas of special value for recreational or hydrological purposes, or for wildlife protection. Felling practices are recommended for 1, 2, 3 and multi-storeyed stands according to stand conditions and susceptibility to windthrow, diseases and insect damage.

1152. DE BYLE, N.V. Harvesting and site treatment influences on the nutrient status of lodgepole pine forests in western Wyoming. Gen. Tech. Report, Intermountain For. and Range Exp. Stn., 1980, INT-90: 137-155
Subject Codes: 3.3
LISC: 575337

Clearcutting and slash treatment produced significant changes in the chemical composition of the soil solution, the surface organic soil horizon, and the surface mineral soil. Most of these changes were greatest under the burned piles of slash. However, the phenol content of the soil solution was highest under the chip mulch, where seedling growth was the poorest. The concentration of nutrients in Pinus contorta seedlings varied little among treatments, despite remarkably different amounts of growth and vigor.

1153. GARY, H.L. Patch clearcuts to manage snow in lodgepole pine. IN: Proceedings of the 1980 Watershed Management Symposium, Vol. 1, Boise, Idaho, July 21-23, 1980. American Society of Engineers, 1980: 335-346
11 ref. 1 pl.
Subject Codes: 6.4
CAB: 1514921

In a study in southern Wyoming, snow-water equivalents were 15-35% greater in clear-felled patches 1, 3 and 5 tree heights in width than in adjacent forest. However, there was decreased snow catch along the downwind forest border. Felled patches affected snow accumulation no further away than the width of the clearing. Placement of a tree and fence barrier reduced the snow deficit along the downwind border of patches. From author's summary.

1154. GONSIOR, M.J., JOHNSON, L.R. 1985. Harvesting systems for lodgepole pine forests. Pages 317-323 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

The alternatives available for harvesting lodgepole pine and the associated cost and environmental effects mainly depend upon stand and terrain characteristics, silvicultural prescriptions, road system characteristics, and proximity and types of wood product markets. Harvesting costs per unit of volume increase at an increasing rate with reductions in tree size. Many systems designed for commercial timber stands prove oversized and costly in smaller lodgepole pine. Reductions in equipment size do not achieve a

corresponding cost reduction sufficient to keep the cost per unit of output at a constant level. Mechanized systems that can produce at levels high enough to offset piece size are limited by both terrain and silvicultural prescription. Steep slopes may require manual felling, which can hamper subsequent mechanization. Thinning may also limit the use of highly mechanized equipment. In selective cuttings, costs may be reduced by bunching to pre-selected trails and using high capacity equipment from that point on.

1155. KOENSTROM, J.C. Effects of clearcutting on nutrient cycling in lodgepole pine forests.
Colo. Div. Game Fish Parks, Fish Res. Rev., 1972, 7: 52 pp
Subject Codes: 3.2, 3.3
BIO: 73042200

1156. LOTAN, J.E. Regeneration of lodgepole pine forests in the northern Rocky Mountains. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 516-535
49 ref.
Subject Codes: N/A
CAB: 757563

Various silvicultural systems are considered, including shelterwood, group selection and seed tree systems, but it is concluded that clear felling is the appropriate method for Pinus contorta at the present time.

## 7.6 TREATMENTS

1157. ADAMS, D.L. Natural regeneration following four treatments of slash on clearcut areas of lodgepole pine - a case history.
Station Note, Forestry, Wildlife and Range Exp. Stn., University of Idaho, 1972, No. 19: 2 pp.
1 ref.
Subject Codes: 7.1, 7.6.1, 7.9
CAB: 106035

Treatments were applied to clear-felled areas of Pinus contorta in N. central Colorado as follows: (a) broadcast burning; (b) crushing slash and residual trees into the ground with a crawler tractor; (c) pushing residual trees and slash into windrows and burning; and (d) trimming the tops of the trees and scattering the slash by hand during logging. After 3-8 years none of the treatments resulted in high percent stocking, but medium stocking was obtained for (a), (b) and (d). It is concluded that natural regeneration is best served by leaving the slash uniformly distributed over the clear-felled area.

1158. BARRING, U. Results of trials in forestry. IN: Weeds and weed control, 19th Swedish Weed Conference, Uppsala, 1978.
Uppsala, Sweden, Sveriges Lantbruksuniversitet, 1978: J1-J10
Subject Codes: N/A
CAB: 1071457

In continuing trials, the effectiveness of triclopyr in controlling Quericus robur and Populus tremula was confirmed. Selective treatments in conifer plantations can be made in August when Pinus and Picea spp. are resistant to the herbicide; resistance of Pinus contorta appeared to be linked with provenance. The good performance of glyphosate at 1.5 kg/ha under Swedish conditions was confirmed; apparent variations in susceptibility of some species in different countries is discussed. Results with Krenite (fosamine) at 6 kg a.i./ha or Krenite at 6 kg a.i./ha + Lissapol, a wetter, were very good, particularly against Betula spp.; B. verrucosa (B. pendula) appeared more susceptible than B. pubescens.

1159. BIGGIN, P. Herbicides for use in forest nurseries.
Scottish Forestry, 1979, 33(1): 9-14
Subject Codes: N/A
BIO: 18003643

1160. HAY, S.J.B., JONES, R.G. The selective use of DPX 3674 (3-cyclohexyl-6-

(dimethylamino)-1-methyl-s-triazine-2,4(1H, 3H)-dione) in UK spruce and pine forests. IN: Proceedings of the EWRS Symposium on Different Methods of Weed Control and Their Integration, Uppsala, 1977.
Biochem. Dep., DuPont (UK) Ltd., Hemel Hemp stead, UK, 1977, Volume 1: 139-147
4 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1008297

In trials carried out in 1976, DPX 3674 at 2 kg/ha applied in the spring controlled Agrostis tenuis, Deschampsia caespitosa and Calamagrostis epigejos as well as many broad-leaved weeds. DPX 3674 at 2-4 kg/ha was also toxic to Rubus, Quercus, Fagus and Betula spp. Calluna vulgaris was only moderately susceptible but control could be improved with surfactants. Pinus nigra, P. sylvestris and P. contorta were unaffected by DPX3674 either in the dormant or in the active growing stages. Picea sitchensis was tolerant and Pseudotsuga menziesii was moderately tolerant provided that spraying was restricted to the dormant period. Larix spp. were severely damaged by the compound regardless of the time of application. From the authors' summary.

1161. HERRING, L.J. Lodgepole pine density control.
B.C. Ministry of For., Res. Rev. 1980-81: 33
Subject Codes: N/A
RCA: X1163

1162. HERRING, L.J. Mechanical spacing in lodgepole pine stands E.P. 789: chemical treatments.
B.C. Ministry of For., Res. Rev., 1980-81: 43
Subject Codes: N/A
RCA: X1164

1163. MAYHEAD, G.J. Use of granular herbicides in upland Britain.
Res. Info. Note, Forestry Commission, UK, 1975, No. 2: 4 pp.
Subject Codes: N/A
CAB: 1107205

Times and rates of application (for Picea sitchensis and Pinus contorta) for the granular herbicides Prefix (7.5% chlorthiamid), Casoron G (7.5% dichlobenil) and Fydulan (7.5% dichlobenil with 10% dalapon) are given. Damage symptoms on trees are described.

1164. PREEST, D.S. A mistblower modification enabling treatment of individual trees with different chemicals.
Pans (Pest Artic News Summ.), 1979, 25(3): 299-301
Subject Codes: N/A
BIO: 19045206

1165. RAE, S.J., PATTERSON, T.M. Scrub weed control with thiazafluron. IN: Proceedings of the 28th New Zealand Weed and Pest Control Conference.
Ciba Geigy, New Zealand Ltd., Christchurch, NZ, 1975: 67-69
1 ref
Subject Codes: 3.5
CAB: 770023

Thiazafluron at 10 kg/ha controlled gorse (Ulex europaeus), blackberry (Rubus fruitcosus), broom (Cytisus scoparius), Himalaya honeysuckle (Leycesteria formosa) and toetoe (Cortaderia spp.) at various sites in S. Island, New Zealand, provided that 200 mm of rain fell within three months of its application. Trees of Pinus contorta less than 2 m high were killed when thiazafluron was applied at 10 kg/ha to an area of 4 m2 at the base of the tree; the effect of the chemical decreased with increasing tree height and was barely detectable on 4-m trees. Stem injection of the herbicide was ineffective. Bracken (Pteridium aquilinum var. esculentum) was not killed by thiazafluron (whereas karbutilate gave good control in the same trial). Residues in the soil were toxic to Pinus radiata, maize and pasture species planted 12 months after herbicide application.

1166. ROWE, J.W., CONNER, A.H., DIEHL, M.A., WROBLEWSKA, H. Effects of treating northern and western conifers with paraquat. IN: Proceedings, Annual Meeting, Lightwood Res. Coordinating Council, Jan. 20-24, 1976, Jacksonville, Florida.
Lightwood Res. Coordinating Council & SE For. Exp. Stn., 1976: 66-76

8 ref.
Subject Codes: N/A
CAB: 961939

Application of 0.25, 1 or 5% aqueous paraquat solution into 10 cm axe frills induced lightwood formation in Tsuga canadensis, Abies balsamea, Larix laricina, Picea abies, P. glauca, P. mariana, Pinus banksiana, P. resinosa, P. strobus and P. sylvestris, but not in P. contorta, P. flexilis, P. ponderosa or Pseudotsuga menziesii. The cambium behind the treatment area was killed in all species and a wedge of dead wood and bark extended up the stems following any spiral grain present. The extent of damage above the wound was directly related to paraquat concn. Species which did not show lightwood induction formed traumatic resin ducts at the edge of wounds, and showed resin exudation on the exterior of the bark. From authors' summary.

1167. SEIDEL, K.W. Suppressed grand fir and Shasta red fir respond well to release.
USDA FOR. Serv. Res. Note, Pacific NW For. & Range Exp. Stn., 1977, No. PNW-288: 7 pp.
6 ref.
Subject Codes: 1.5, 7.7, 8.6
CAB: 1022387

Plots in a stand at 1706 m in Oregon with a 75-year-old overstory of Pinus contorta and a 43-year-old understory of grand fir (Abies grandis) and Shasta red fir (Abies magnifica var. shastensis) were thinned to one of 4 spacings (6, 12, 18 or 24') in 1970 or were thinned to 6' in 1970 and progressively thinned over a period of years to 24'. the overstory was killed with 2,4-D. During the 5 years after release, diameter and height increment did not differ significantly between spacings. Diam. increment increased from 0.04"/year in the 5 years before release to 0.11"/year in the 5 years after release; the response was evident in the first year after release. Similarly, height increment increased from 0.2'/year to 0.4'/year. Crown diameter increased by 1.6' for A. grandis and by 1.8' for A. magnifica var. shastensis during the 5 years after release.

1168. SHAUKAT, S.S., LOVELL, P.H., MOORE, K.G. The effects of simazine atrazine and 2 4-D on germination and seedling development of some Pinus-spp.
Proc. Pak. Sci. Conf., 1975, 25(3): D-16-D-17
Subject Codes: N/A
BIO: 76019193

1169. WORT, D.J., KOZAK, A. Napthenate stimulation of conifer growth over a 3 year period.
Canadian Journal of Forest Research, 1976, 6(2): 233-239
16 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.3
CAB: 892341

Bare-root 1 + 0 seedlings of Pseudotsuga menziesii, Pinus contorta, Picea sitchensis and Tsuga heterophylla, and Pseudotsuga menziesii seedlings in plastic bullets were planted out in a research forest in British Columbia and were sprayed with solutions of 2000 and 5000 ppm K naphtenate on 1, 18 or 30 May, 1972. Terminal and lateral bud development at the time of spraying was classified as : (a) buds unopened, no stem growth: (b) terminal bud open, little or no stem growth; or (c) terminal bud open, lateral buds opening and stem growth started. Ht. measurement at the time of spraying and at the end of the following 3 growing seasons showed that stage (c) was the best time for application. The more effect concn. was 5000 ppm, except for Pseudotsuga menziesii in bullets. The effect of application decreased with time: the av. ht. growth of stage (c) plants sprayed with 5000 ppm solution was 44.5, 25.2 and 15.2% greater than controls after 1, 2 and 3 yr resp. The most responsive species to the 5000 ppm solution was Picea sitchensis.

## 7.6.1 SCARIFICATION

1170. CROSSLEY, D.I. Mechanical scarification and strip clearcutting to induce lodgepole pine regeneration.
Can. Dep. North. Aff. and Nat. Resour., For. Br., For. Res. Div., Tech. Note 34, Ottawa, Ont., 1956: 14 pp.
Subject Codes: 7.5
RCA: X1020

1171. GLEN, L.M., ACKERMAN, G.C. Proposed amendments to the regeneration survey system used on drag scarified lodgepole pine sites in the Prince George Forest District.
Res. Notes, British Columbia Forest Service, 1978, No. 84: 7 pp.
3 ref.
Subject Codes: N/A
CAB: 1118664

Initial experience with the system is described and the following recommendations made: the method of anchor-chain, drag-scarification (DS) (wt. and type of attachments) should be determined by site factors such as number of cones, duff depth and slash rating; on areas with an abundant seed source, stocking could be controlled by delaying DS up to one season after logging or by the appropriate selection and configuration of drag attachments and subsequent scarifying technique; surveys should be delayed until the fifth growing season after scarification, subsequent to the constraints of seed supply and adequate DS; the present survey should be redesigned to provide information on stocking as well as stock distribution; and a standard form containing all pertinent logging, scarification and regeneration data is essential.

1172. JOHNSON, H.J. Pre-scarification and strip clear cutting to obtain lodgepole pine (Pinus-contorta-var-latifolia) regeneration.
Forest Chron., 1968, 44(6): 27-30
Subject Codes: 7.5
BIO: 50100496

1173. MCMINN, R.G. Effect of four site treatments on survival and growth on white spruce and lodgepole pine seedlings.
Bi-monthly Research Notes, 1974, 30(3): 19-20
3 ref.
Subject Codes: 7.4.3
CAB: 380409

Gives results of a field trial in British Columbia in 1972. The trial was made to evaluate the survival % and height increment during the second growing season of Picea glauca and Pinus contorta var. latifolia planted, after the previous Spruce/Fir stand had been clear felled, (a) on undisturbed ground, (b) after removal of ground vegetation and litter, (c) after repeated removal of ground vegetation but not litter, or (d) after mechanical mixing (by rotovator) of the ground vegetation and litter into the mineral soil. Survival of both species was good with all treatments, and treatment (d) gave the best height growth. Reasons are suggested.

1174. MOHLER, J.P., GOLSON, R.E. Hydro-Ax and Nicolas Hydro-Mulcher test report.
DNR Notes, Dept. of Nat. Res. Washington, 1975, No. 10: 12 pp.
Subject Codes: 7.5, 7.7
CAB: 769984

The Hydro-Ax (manufactured by National Hydro-Ax, Inc., of Minnesota) was originally built to crush and grind up small-diameter standing brush on gentle slopes. It has also been used for pre-commercial thinning of pine. Trials of the Hydro-Ax and Hydro- Mulcher cutting heads, for reduction of felling slash, were made in late 1974, on a clear-felled, second-growth Douglas-fir/lodgepole pine site that had been logged less than 1 year previously. Both cutting heads were mounted on the same prime carrier, for which detailed specifications are given. Results of the tests showed that the Hydro- Mulcher treated the residue and ground vegetation more completely than did the Hydro- Ax. Two passes with the Hydro-Ax were made at 0.5 acre/hour; the Hydro-Mulcher only covers about 0.2-0.3 acre/hour.

1175. O'CARROLL, N., CAREY, M.L., HENDRICK, E., DILLON, J. The tunnel plough in

peatland afforestation.
Irish Forestry, 1981, 38(1): 27-40
10 ref., 1 pl.
Subject Codes: 7.4
CAB: 1487335

Two experiments were set up in Glenamoy Forest, Irish Republic, in 1960 and 1967, to compare growth of Sitka spruce and lodgepole pine on blanket bog peat. Ploughing was carried out using: (1) double or single-mouldboard ploughs at 1.5 and 3.0 m spacing giving an open furrow with a planting ridge on one side; (2) a ugh at 1.5, 3.0 and 4.5 m spacing, giving a closed drain with a planting ridge on top. There was n.s.d. between treatments for ht. or d.b.h. of Sitka spruce measured at 12 or 15 years; ht. of lodgepole pine was significantly greater at 12 years using (2). The water table was consistently lower with (2) than with (1). The greatest effect being obtained at 3.0 m spacing. Trees rooted deeper, the air content of the peat was greater and the percentage water smaller on type (2) sites.

1176. THOMPSON, C.F. Drag scarification trials in lodgepole pine logging slash in the Nelson Forest district of British Columbia.
Research Note, Ministry of Forests, British Columbia, 1978, No. 82: ii + 13 pp.
9 ref.
Subject Codes: 4.2, 6.6
CAB: 1566787

Six logged lodgepole pine sites were drag scarified in 1972 or 1973, and examined for seedbed quality, cone supply and 4th-year regeneration. Scarification reduced the number of cones from an average 31/m2 to 17/m2, but cone supply was considered limiting on only one site. Regeneration was better where scarification occurred soon after logging (i.e. less seed had been released due to summer heat). Regeneration was best on mineral soil or mixed mineral soil/duff. Factors influencing the cost of scarification are discussed. In stands of lodgepole pine in British Columbia with stocking densities of 8,333-40,000 stems/ha with average diameter of 80.1-46.8 mm, the proportion of potential crop trees damaged by hares (Lepus americanus) was 30%, and by squirrels (Tamiasciurus hudsonicus) 37.7%. The proportion of trees damaged by hares increased with stocking density, whereas squirrel damage decreased. The number of wounds made by hares also increased with stocking whereas those made by squirrels showed little difference. For both animals the average surface area of bark and cambium removed per wound increased with tree stocking.

1177. THOMSON, J.H., NEUSTEIN, S.A. An experiment in intensive cultivation on an upland heath.
Scottish Forestry, 1973, 27(3): 211-221
4 ref.
Subject Codes: N/A
CAB: 234881

Describes an experiment at Teindland Forest, Morayshire, to compare the effects of six ploughing treatments (two deep spaced-furrow treatments; shallow complete ploughing; shallow complete ploughing plus subsoiling; deep complete ploughing; and deep complete ploughing followed by rotovator cultivation) on the growth of Scots Pine, which is the native and traditional species in this region, and a lodgepole pine/Japanese larch mixture, considered to be the most economic crop for the site. In addition, four possible alternative species, viz. Douglas-fir, Sitka spruce, Norway spruce and western hemlock, all nursed by Japanese larch, were represented in small subsidiary plots. The soil was ironpan podzol derivative on indurated material. Data are given on: the volume of soil disturbed by the various treatments and the extent of pan breakage; height growth of the trees up to 20 years of age; height growth of the trees in the 21st year, 2 years after top dressing with PK; the total production (volume and b.a.) of the three main species at 20 years of age; and the root and stem form of Scots Pine, and the stem form of lodgepole pine in relation to ploughing treatment. Up to 15 years of age, the best results were obtained with deep complete ploughing. However, rate of growth for this treatment has decreased, and growth trends for other treatments have also changed, with the result that it is impossible to predict the future outcome of the experiment or to estimate what yield classes will finally be achieved. Various possible reasons for these changes are discussed in detail.

1178. WINSTON, D.A., SCHNEIDER, G. Conifer establishment by hand seeding on sites prepared with the Brackekultivatorn.
Report, Great Lakes For. Res. Centre, Canada, 1977, No. O-X-255: 3 + 11 pp.
10 ref., 1 pl.

Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1431620

Both dry and moist sites in Ontario were prepared with the Bracke cultivator; after 6 growing seasons, stocking of Pinus banksiana, P. contorta and P. banksiana X contorta was at "desireable" rates (Province of Ontario minimum stocking standards); Picea mariana stocking was below the "desireable" rate but better than previously reported average results.

## 7.6.2 JUVENILE STAND TENDING

1179. ANON. Strip thinning of juvenile lodgepole pine - Cariboo Forest Region. IN: SISCO Spring Newsletter, 1983, Southern Silviculture Committee, Nelson, B.C.
Subject Codes: 7.7
RCA: X1149

1180. ABRAHAMSON, L.P., BURNS, K.F. Herbicide screening for weed control in western forest nurseries - Great Plains segment.
AFRI Research Report, Applied Forestry Research Institute, State University of New York, 1979, No. 41: 15 pp.
Subject Codes: 7.3
CAB: 1246930

Twelve herbicides were applied either after seeding or after germination to 7 conifers and 5 broadleaved species in 6 nurseries. Weeds were collected from nursery plots and weighed. Survival and ht. of treated tree seedlings is tabulated as a % of control values; phytotoxicity was variable. Post-seeding treatments were usually more effective.

1181. ALLEN, M.G. An evaluation of methods and timing of application of candidate selective herbicides in young forest plantations. IN: Proc. of the 12th British Weed Control Conference.
London, UK, British Crop Protection Council, 1974: 271-278
8 ref.
Subject Codes: N/A
CAB: 503014

In 3 trials initiated in 1973 and 8 initiated in 1974 in plantations of Picea sitchensis, Pinus contorta, and Acer pseudoplatanus in the UK, chlorthiamid granules at 4.2 kg and atrazine w.p. (wettable powder) at 4.48 kg/ha as standards were compared with cyanazine + atrazine w.p. and suspension concentrate, cyanazine as a suspension concentrate and granular formulation, and cyanazine + dalapon and chlorthiamid + dalapon granules. At the 3 sites assessed, cyanazine + atrazine (each component 3.58 kg/ha) was the most consistent treatment at all dates, giving acceptable weed control up to 18 months after applications, and was effective when applied in very low spray volume (9.8 litres/ha). Chlorthiamid + dalapon and chlorthiamid alone were also effective. All effective treatments gave increased tree growth.

1182. BIGGIN, P. Weed control in conifer transplant lines. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in forestry, April 1-2, 1980.
For. Comm., Northern Res. Sta., Roslin, Midlothian, UK, 1980: 175-181
9 ref.
Subject Codes: 7.3
CAB: 1203020

The potential of simazine, diphenamid, nitrofen, propyzamide, MCPA and glyphosate in controlling persistent weeds (such as Equisetum arvense and Rumex acetosella)

is discussed in the light of experiments carried out in 1975-79 in transplant lines of Picea sitchensis and Pinus contorta at various nurseries in Britain.

1183. COLE, D.M. Herbicides used for control of lesser vegetation damage young lodgepole pine.
USDA For. Serv. Res. Note, Intermountain For. & Range Exp. Stn., 1976, No. INT-211: 5 pp.
7 ref.
Subject Codes: N/A
CAB: 939600

Natural stands of 8 to 10-yr-old lodgepole pine (Pinus contorta) at 6400' alt. in central Montana were thinned in August 1965. In August 1966 herbicide (5 lb a.i. dalapon, 4.5 lb. a.e. 2,4-D and 4.5 lb a.e., 2,4,5-T per 100 gal water) was applied to understory vegetation which consisted mainly of Vaccinium scoparium, lupin (Lupinus spp.) and Carex geyeri. One year after spraying, mortality of young lodgepole pines was 7%, and 52% were damaged (nearly half of these seriously); all understory vegetation was killed. At 2 years after spraying, mortality was 16%, and sprayed areas were occupied by cheatgrass (Bromus tectorum). At 3 years there was no further motality. At 4 years after treatment, average 6-year height increment of pine was found to be significantly less on sprayed plots; lupin had become re-established.

1184. DAVENHILL, N.A., PREEST, D.S. Interim evaluation of several soil sterilants for the control of contorta pine. IN: Proceedings of the 27th New Zealand Weed and Pest Control Conference, Nelson.
Weed Abstracts 24, 1287, OW., 1974: 19-23
Subject Codes: 7.4.4, 8.8
CAB: 514381

Pinus contorta is a valuable pioneer for erosion control and site rehabilitation at high altitudes in New Zealand, but its uninhibited spread in the Waiouru Military Reserve and Tongariro National Park has earned it the disapproval of the Defence Department and conservationists. A chemical control trial showed that bromacil, thiazfluron and karbutilate at 17 kg/ha, applied to 2.3 m2 of rooting zone, can kill young trees. Treatment in Dec. was better than in Oct.

1185. DRAPER, D.A. Response of low-merchantability, repressed lodgepole pine trees to spacing and fertilization. E.P. 886.03. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 53
Subject Codes: 7.8
RCA: X1063

1186. GILCHRIST, A.J. Control of woody weeds in forestry with triclopyr. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in forestry, April 1-2, 1980
Dow Chemical Co. Ltd., Hounslow, Middlesex, UK, 1980: 249-256
4 ref.
Subject Codes: N/A
CAB: 1203026

1187. GLEN, L.M. Spacing lodgepole pine with a Hydro-Ax.
Unpublished Paper Presented at C.I.F. Juvenile Spacing Workshop, Nanaimo, B.C., Oct., 1976
Subject Codes: N/A
RCA: X1161

1188. HERRING, L.J. Fertilizer related density control of lodgepole pine. E.P. 789.03. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 50
Subject Codes: N/A
RCA: X1058

1189. HERRING, L.J. Herbicidal density control of lodgepole pine stands. E.P. 789.05. IN: Forest Research Review, 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 51
Subject Codes: 7.6
RCA: X1059

1190. JOHNSTONE, W.D. Effects of spacing 7-year old lodgepole pine in west-central Alberta.
Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-236, 1981
Subject Codes: N/A
RCA: X1065

1191. JOHNSTONE, W.D. Juvenile spacing of 25-year-old lodgepole pine in western Alberta.
Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-244, 1982: 19 pp.
22 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
RCA: X1116

The effects of spacing 25-year-old fire-origin lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in western Alberta are reported 10 years after treatment. Data were analyzed in terms of the entire stand and portions of it. Spacing had a significant effect on stand and crop-tree growth and development. Wide spacing resulted in greater diameter increments and greater stand and crop-tree average diameters.

1192. JONES, R.G., JONES, R.G. Scrub control with fosamine ammonium (Krenite). IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in forestry, April 1-2, 1980.
Shell Chemicals UK Ltd., Ely, Cambridgeshire, UK, 1980: 139-145
1 ref.
Subject Codes: N/A
CAB: 1203015

1193. JONES, R.G., JONES, R.G. Weed competition, changing weed composition and tree growth following herbicide application. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in Forestry, April 1- 2, 1980.
Shell Chemicals UK Ltd., Ely, Cambridgeshire, UK, 1980: 65-72
6 ref.
Subject Codes: 7.3
CAB: 1203008

Trials in young plantations of Picea abies, P. sitchensis, and Pinus contorta in Scotland are reported.

1194. JONES, R.G., JONES, R.G., SCOTT, E., GODDING, S.J. An evaluation of hexazinone as a selective forestry herbicide. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in Forestry, April 1- 2, 1980
Shell Chemicals, UK Ltd., Ely, Cambridgeshire, UK, 1980: 227-234
Subject Codes: N/A
CAB: 1203025

1195. MACKENZIE, J.M. Fertilizer/herbicide trials on Sitka spruce in east Scotland.
Scottish Forestry, 1974, 28(3): 211-221
5 ref.
Subject Codes: 7.8
CAB: 363374

Presents the results of experiments in four young plantations on different sites in East Scotland, assessed five years after treatment with NPK fertilizer and/or 2, 4-D (to control heather). Results are shown in tables and graphs. Height increment of Picea sitchensis was most influenced by treatment with fertilizer on peaty iron-pan sites; on the poorer deep-peat sites the combined treatment was best. Pinus contorta var. latifolia and Pinus sylvestris showed little response to any treatment. Measurements of nutrient concentrations in foliage showed that deficiencies of P and N limit the growth of P. sitchensis on all sites and poorer sites respectively, and K deficiency is a contributory factor on the deep, unflushed peats. N deficiency can be cured temporarily by applying N fertilizer or by controlling heather. On some sites the application of phosphate plus herbicide has already proved economic, only 5 years after treatment, but it remains to be seen whether the application of larger amounts can be fully justified on the poorer sites.

1196. MCCAVISH, W.J. Hexazinone - a new forest herbicide. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in Forestry, April 1-2, 1980.
For. Res. Sta., Alice Holt Lodge, Wrecclesham, Farnham, Surrey, UK, 1980: 217-225
10 ref.
Subject Codes: N/A
CAB: 1203024

A summary of the results of nursery and forest experiments carried out by the Forestry Commission in Britain in 1977 and 1978, giving information on the susceptibility of weeds and the tolerance of conifers to various doses of the herbicide applied in March- July. The conifer species included are: Larix leptolepis, Picea abies, P. sitchensis, Pinus contorta, P. nigra, P. sylvestris, Pseudotsuga menziesii and Tsuga heterophylla.

1197. POLLACK, J. Spacing trials of lodgepole pine. E.P. 671. IN: Forest Research Review 1981-82
Ministry of Forests, Victoria, B.C., 1983: 50
Subject Codes: N/A
RCA: X1057

1198. POWELL, J.M. Use of gramoxone (R) to control mosses and liverworts in greenhouse pots.
Bi-monthly Research Notes, 1975, 31(5): 35-36
4 ref.
Summary Languages: N/A
Subject Codes: 7.3
CAB: 564557

Describes trials to assess the ability of Gramoxone (paraquat) to control moss and liverwort growth on pots containing transplanted Pinus contorta seedlings 1/2 m high, kept for 20 months in a greenhouse. The herbicide was applied at 9 ml/litre or 4.5 ml/litre; both concentrations proved equally effective. One month after treatment, 85% of the mosses and 100% of the liverworts had been killed, and little regrowth occurred in the next 7 months.

1199. RICHARDSON, W.G., TURNER, D.J. Pot experiments to evaluate treatments for seedbed use in forest nurseries. IN: Association of Applied Biologists: Proceedings of the Conference on Weed Control in Forestry, April 1-2, 1980.
ARC Weed Res. Org., Begbroke Hill, Yarnton, Oxford, UK, 1980: 167-174.
6 ref.
Subject Codes: N/A
CAB: 1203019

In two outdoor experiments in 1978 and 1979 a total of 43 herbicides and 9 mixtures were tested for pre- and post-emergence selectivity on Larix leptolepis, Picea sitchensis, Pinus contorta, P. nigra, Pseudotsuga taxifolia (P. menziesii), Acer pseudoplatanus, Betula pubescens and Nothofagus procera.

1200. STEWART, R.E. Herbicides for control of western swordfern and western bracken.
USDA For. Serv. Res. Note, Pacific NW For. & Range Exp. Stn., 1976, No. PNW-284: 11 pp.
19 ref., 2 pl.
Subject Codes: 7.1
CAB: 984165

Foliar sprays of asulam, bromacil, dicamba, dichlobenil, or picloram were applied in May/June or July/August, 1970 to western swordfern (Polystichum munitum) and western bracken (Pteridium aquilinum var. pubescens) in Oregon; survival was determined in September, 1971. Dicamba (3 lb a.i. in 100 gal water) gave best control of Polystichum munitum when applied in either spring or mid-summer. In order to prevent damage to conifers dicamba should be applied to individual ferns. Asulam (1-3 lb/acre a.i.) gave the most satisfactory control of Pteridium aquilinum and did not affect the survival of Pinus contorta or Pseudotsuga

menziesii in trials in western Washington.

1201. STEWART, R.E. Herbicides for weed control in western forest nurseries.
Proceedings, Western Society of Wood Science, 1977, (30): 78-89
6 ref.
Subject Codes: N/A
CAB: 1406916

Preliminary results are given of a research program to identify promising herbicides. The effects of 17 herbicides on herbaceous weeds and on 12 conifers (5 species of pine, 4 of fir, Douglas-fir, western hemlock and coast redwood - Sequoia sempervirens) were evaluated at 13 nurseries in Oregon, Washington and California. Data are tabulated showing the effect of herbicides on dry weight of weeds and giving damage ratings for the coniferous seedlings when herbicides were applied before or after sowing or after germination. Pines were the most resistant, and hemlock and redwood the most sensitive. Recommendations are made for timing of application and dosages.

1202. STEWART, R.E., OWSTON, P.W., WEATHERLY, H.G. Evaluation of six herbicides for weed control in Pacific Coast forest nurseries. IN: Proceedings, Nurserymen's Conference and Seed Processing Workshop, Eureka, California, Aug. 7-11, 1978.
Div. Timber Mgt. Res., USDA For. Service, Washington, D.C., 1978, B-127 - B-133
5 ref.
Subject Codes: 7.3
CAB: 1455508

Herbicides identified as promising in previous work have been tested at 14 nurseries to evaluate their effectiveness in herbaceous weed control and toxicity to 11 coniferous species. The herbicides (bifenox, butralin, DCPA, diphenamid, napropamide and hexazinone) were applied to nursery beds (a) 2 days after sowing, (b) 4-5 weeks after seedling emergence and 1 week or less after weeding, or (c), (a) + (b). Hand weeding times are given for each treatment. Work on the effects of the herbicides on mycorrhizae is also reviewed. Only hexazinone consistently damaged seedlings, although DCPA damages western hemlock when applied in (a).

1203. TURNER, D.J., RICHARDSON, W.G. Pot experiments at the Weed Research Organization with forest crop and weed species.
Tech. Rep., ARC Weed Research Organization, 1978, No. 46: 16 pp.
Subject Codes: N/A
CAB: 1055471

Results are presented of three post-emergence and two pre-emergence pot experiments, involving Picea sitchensis, Pinus nigra (Corsican pine), Pinus contorta, iesii, Thuja plicata, Quercus petraea, Fagus sylvatica, heather (Calluna vulgaris) and the grasses Molinia caerulea, Deschampsia caespitosa and Calamagrostis epigejos. Some herbicides not now used in forestry may be useful for controlling weeds in nurseries, transplant lines or young plantations. MCPA-salt with added ammonium sulphate or various triazine herbicides may also be useful against heather.

1204. VAN DEN DRIESSCHE, R. Relationship between spacing and nitrogen fertilization of seedlings in the nursery, seedling size, and outplanting performance.
Can. J. of For. Res. Vol. 12(4) Dec. 1982: 865-875
19 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.8
RCA: X1128

Nursery sowings of coastal and interior varieties of Douglas-fir, Sitka spruce and lodgepole pine (Pinus contorta Dougl.) were thinned to different spacings 5 weeks after germination. Spacings in the drills, which were 15 cm apart, were 1, 2, 4, 8 and 12 cm with the nursery sowing rate (about 0.6 cm spacing) as control. Spacings were applied seedlings were planted out at Campbell River (coastal Douglas-fir) and Port Alice (Sitka spruce), both on Vancouver Island, and at Lyne Creek (interior Douglas-fir) in the Cariboo region and at Fulton Lake (lodgepole pine) in the Prince Rupert region of British Columbia. Wider spacing and greater N supply increased 2-0 seedling dry weight, root- collar diameter and shoot height

and also affected distribution of dry matter between needles, stems and roots. Wider spacing increased survival of outplanted interior Douglas-fir by 12%. Survival of coastal Douglas-fir and Sitka spruce species was high and only increased 4 to 7% due to wide spacing after one season, but after three seasons wide spacing increased survival 17-19%. Compared with control, 12 cm spacing and increased first-season shoot growth 53% for coastal Douglas-fir, 82% for interior Douglas-fir, and 71% for Sitka spruce. Second-season shoot growth of lodgepole pine was increased 92% by the widest spacing. Much of the improved growth was explained in terms of increased seedling size. At the highest level of N supply, increasing spacing to 4 cm did not greatly reduce yield of seedlings with root-collar diameters greater than 3 mm, except for interior Douglas-fir. Thus moderate increase in spacing improved quality without materially reducing yield of seedlings per unit area of nursery. Nursery fertilization at 235 kg N ha-1 increased new shoot growth one season after planting by 36-58% compared with the 60 kg N ha-1.

1205. VAN DORSSER, J.C. Nursery weed control.
Report of Forest Research Institute for 1970, New Zealand Forest Service, 1971: 35 pp.
Subject Codes: 7.3
CAB: 051923

1206. VAN DORSSER, J.C. Current research into weed control in forest nurseries.
Proceedings, 24th New Zealand Weed and Pest Control Conference, 1971: 56-58
Subject Codes: N/A
CAB: 098370

Propazine at 0.5-1 lb/acre and chlorthal at 10 lb/acre, applied before emergence, gave effective control of germinating weeds in Pinus radiata nurseries; chlorthal controls Digitaria sanguinalis. The search for selective chemicals for use soon after emergence has continued. Atrazine at 2 lb+ emulsifiable oil at 2 gal/acre was safe and effective in P. radiata Greater than 4 in high. Chloramben at 5 lb/acre, applied soon after sowing, showed promise when used on Pseudotsuga menziesii seedbeds, and nitrofen at greater than 4.5 lb/acre has shown promise in Pinus contorta var. latifolia in recent trials; the crops tolerated twice the above rates. Linuron at 0.5-1 lb/acre, applied before emergence (2 days after sowing), is recommended for Eucalyptus spp.

1207. VAN DORSSER, J.C. The use of herbicides in forest nurseries (in New Zealand).
Proceedings of the 4th Asian-Pacific Weed Society Society Conference, Rotorua, 1973: 279-283
1 ref.
Subject Codes: 7.3
CAB: 400037

Pinus radiata is sown in Sep./Oct. and propazine 0.56-1.12 kg/ha is applied before emergence to control a wide range of broadleaved weeds and annual grasses; chlorthal- dimethyl at 9-10 kg/ha is added if necessary to control Digitaria sanguinalis. Nitrofen at 7-9 kg/ha is recommended for pre-emergence and early post-emergence control in Pinus contorta and Pseudotsuga menziesii, species sensitive to propazine; 8 weeks after emergence, propazine and chlorthaldimethyl, which gave longer-lasting control, may be substituted for nitrofen. Under moist conditions, diphenamid at 11-14 kg/ha, which gives excellent broad-spectrum control in P. menziesii and P. radiata seedbeds, can be used in place of nitrofen from the time of sowing onwards. For Eucalyptus spp., linuron at 1.12 kg/ha is a proven pre-emergence herbicide on heavy soils; nitrofen at 6.7 kg/ha before emergence, so far tested only in E. delegatensis, appears a promising alternative to linuron on lighter, drier soils.

1208. WEBSTER, R.J. A trial with atrazine, and some thoughts on why we tried it.
Quarterly Journal of Forestry, 1971, 66(2): 133-138
1 ref.
Subject Codes: N/A
CAB: 051951

Discusses experience gained from a trial application of atrazine (as a 50% wettable powder) at 3 or 5 1/2 lb. a.i./acre to control grass in a young plantation of Corsican pine, Scots pine, and lodgepole pine, with a few European larch, on a base-rich loam over limestone in Derbyshire.

1209. WESTON, G.D., CARLSON, L.W., WAMBOLD, E.C. The effect of growth retardants and inhibitors on container-grown Pinus contorta and Picea glauca.
Canadian Journal of Forest Research, 1980, 10(4): 510-516
23 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.3
CAB: 1329432

Shoot and root growth were reduced to different extents by the 13 compounds, thus causing alterations in shoot/root ratios. The results are discussed with regard to the potential use of these chemicals for enhancing survival after outplanting or for use in held-over material. Ancymidol, Ethrel (ethephon), phosphon and Maintain caused reductions in the shoot/root ratio and may have potential for use in material to be planted out. CCC (chlormequat), RH531, Ethrel, and mefluidide appear to have potential for use in held-over materials. From authors' summary.

## 7.7 THINNING

1210. ANON. Forest production studies: thinning. Report of the Minister for Lands on the Forest and Wildlife Service for the period from 1st April, 1970 to 31st March, 1971.
Dublin, Irish Republic, 1972: 28
Subject Codes: N/A
CAB: 114266

Results to date from thinning experiments indicate that for Picea sitchensis, P. abies and Pinus contorta, a first thinning removing up to 33% of volume has little effect on increment, and a second thinning may remove as much as 50% (of standing volume) without serious loss of increment. For Pinus sylvestris, removal in both first and second thinnings must be much less in order to avoid loss of increment.

1211. ADAMS, D.L., ALLEN, G.M. Lumber production from "precommercial" thinnings in northern Idaho.
Station Paper, Forest, Wildlife and Range Exp. Stn., University of Idaho, 1974, No. 16: 11 pp.
5 ref.
Subject Codes: 8.1, 8.5
CAB: 371795

Presents an analysis of costs and income in a thinning operation (of the type normally described as 'pre-commercial') in a 20-acre 75-year-old stand of Douglas-fir, lodgepole pine and grand fir. The results suggested that such stand-improvement measures could pay for themselves.

1212. BELLA, I.E. Thinning young lodgepole pine is faster with a brush saw.
Forestry Chronicle, 1974, 50(4): 153-154
3 ref.
Subject Codes: N/A
CAB: 380459

Describes and illustrates a study on the use of a Husqvarna 165 R 'brush saw' (a portable circular saw) for thinning (a) a dense, unthinned 16-year-old Pinus contorta stand with up to 40,000 stems/acre, and (b) a strip-thinned, 33-year-old P. contorta stand containing 19,000 stems/acre. Data on the thinning rates achieved are tabulated and discussed. It is concluded that in stands such as (a) an experienced worker, using the saw tested, should be able to thin an acre per average working day.

1213. BELLA, I.E. Growth of young lodgepole pine after mechanical strip thinning in Alberta.
Info. Report, Northern Forest Research Centre, Canada, 1972, No. NOR-X-23: 15 pp.

4 ref.
Subject Codes: N/A
CAB: 122149

Dense 25-year-old stands of Pinus contorta var. latifolia of mean height 9 ft that had originated after fires, were thinned mechanically by clearing strips to 10.5 ft wide with a drum chopper. A special attachment guided the trees into the path of the chopper and eliminated bent or hanging trees along strip edges. The alternate untreated strips were 4-6 ft wide. There was a substantial increase during the first 5 years after thinning in the diameter increment of trees in all size classes in the dense stands (19 000 trees/acre within the strips), but in more open stands (11 000 trees/acre within the strips) the response was light.

1214. BELLA, I.E., DE FRANCESCHI, J.P. Young lodgepole pine responds to strip thinning, but ...
Info. Rep., Northern Research Centre, Canada, 1977, No. NOR-X-192: 10 pp.
3 ref.
Language: en
Summary Languages: fr
Subject Codes: 5.2
CAB: 1369052

Results are presented 10 years after strip thinning in a 25-year old stand composed mainly of Pinus contorta var. latifolia in SW Alberta; results at 5 years were reported earlier. Over the second 5-year period, average b.a. increment was 87% greater than controls in densest stands, 64% in medium density stands, and 51% in open stands. Mortality (greater in denser stands) was n.s.d. in relation to thinning. It is recommended that strip thinning be restricted to overdense Pinus stands, followed, within 5 years, by selective thinning.

1215. BELLA, I.E., DE FRANCESCHI, J.P. Growth of lodgepole pine after mechanical strip thinning in Alberta: 15-year results.
Forestry Chronicle, 1982, 58(3): 131-135
4 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: 5.1
CAB: 1569833

In a stand of Pinus contorta thinned at 25 years by 3.2 m-wide swaths alternating with 1.2-1.8 m residual strips, d.b.h., b.a. and height increments from 10 to 15 years after treatment were up to 50% greater in thinned plots than in controls. The release effect extended throughout the residual strip. Mortality increased with stand density in all plots, but was similar for thinned and unthinned strips.

1216. DAHMS, W.G. 55 year old lodgepole pine responds to thinning.
US For. Serv. Research Note PNW-141, 1971: 1-13
Subject Codes: N/A
BIO: 71080900

1217. DAHMS, W.G. Growth and soil moisture in thinned lodgepole pine.
USDA For. Serv. Research Paper, Pacific NW For. and Range Exp. Stn., 1971, No. PNW-127: 32 pp.
17 ref.
Subject Codes: 2.11, 2.2, 5.1
CAB: 091276

Reports a detailed study of the Pinus contorta stand in central Oregon already described, including measurements of soil moisture by means of a neutron probe, during the 10 years since 1959 (when the stand was 22 years old). The stand was thinned three times to a range of bole-area specifications in 1959, 1964 and 1969. Measurements before and after the last thinning showed that trees at lower stand densities had longer crowns and grew more rapidly in diameter, but not significantly faster in height. Gross volume increment and withdrawal of soil moisture decreased with decreasing stand density. Understory vegetation did not develop strongly even at low stand densities.

1218. DAHMS, W.G. Growth response in lodgepole pine following precommercial thinning.
IN: Precommercial Thinning of Coastal and Intermountain Forests in the Pacific

Northwest.
Wash. State Univ., Pullman, Wash., 1971: 14-18
Subject Codes: N/A
RCA: X1077

1219. DAHMS, W.G. Tree growth and water use response to thinning in a 47-year-old lodgepole pine stand.
USDA For. Serv. Research Note, Pacific NW For. and Range Exp. Stn., 1973, No. PNW-194: 14 pp.
12 ref.
Subject Codes: 8.8.3
CAB: 234935

Presents a study on the effects (after 5 years) of thinning a dense stand of Pinus contorta in central Oregon to a range of bole-area specifications. Data collected in 1967 showed that mean diameter increment of the 100 largest trees per acre appeared to reach a maximum at the second lowest density (47.9 ft2 b.a./acre). There was no general correlation between height growth and stand density, but the height increment of the larger trees was reduced by thinning, especially at low stand densities. Stand volume increment increased irregularly with increasing stand density, probably owing to variations in site quality and stand density before thinning. Soil moisture withdrawal was substantially reduced at lower stand densities and it is suggested that one of the principal results of thinning will be an increase in stream flow.

1220. GALLAGHER, G.J. The development of thinning systems in young Sitka spruce and contorta pine crops.
Bulletin, Forestry Commission, UK, 1976, No. 55: 49-55
8 ref.
Subject Codes: N/A
CAB: 817031

The results and economics are discussed of various types and intensities of thinning in plantations of Picea sitchensis or Pinus contorta in the Irish Republic. It is concluded that row thinnings of moderately heavy intensity (removal of 33% of the standing volume in the first thinning) will be feasible for Sitka spruce. Results were less clear for contorta pine; no definite trend was discernible over a range of thinning intensities. Windthrow may cause considerable damage after thinning contorta pine in Ireland.

1221. GALLAGHER, G.J., O'BRIEN, D., LYNCH, T.J. Silvicultural and economic aspects of spacing and thinning in Sitka spruce and lodgepole pine.
Schriften, Forstliche Fakultat, Universitat Gottingen/Niedersachsische Forst liche Versuchsanstalt, 1980, 67: 193-205
7 ref.
Language: en
Summary Languages: de, fr
Subject Codes: 7.6.2, 8.5
CAB: 1556514

1222. HAWKSWORTH, F.G. Intermediate cuttings in mistletoe-infested lodgepole pine and southwestern ponderosa pine stands.
Gen. Tech. Rep., USDA For. Serv., Pacific SW For. and Range Exp. Stn., 1978, PSW-31: 86-92
Subject Codes: 6.1
LISC: 265353

Intermediate cuts in mistletoe (Arceuthobium americanum) infested lodgepole pine (Pinus contorta) and ponderosa pine (Pinus ponderosa) stand include "sanitation cuttings" (where all visibly infected trees are cut) and "sanitation thinnings" (where emphasis is on spacing and cutting the trees that are most heavily infected). Sanitation cuttings are recommended only in stands where less than about 40% of the trees are infected. Usually such stands are less than 30 years old. Sanitation thinnings are usually applied to stands over 30 years, but are not recommended in heavily infested stands because heavily infected residual trees will show little response to thinning. Presently, we do not suggest thinning in stands with an average dwarf mistletoe rating (6-class system) of 3 or more. Yield simulation procedures are available for mistletoe-infested lodgepole pine stands in the central Rockies and for southwestern ponderosa pine.

1223. HEDIN, I.B. Five case studies of precommercial thinning in British Columbia and Alberta.

FERIC Technical Note No. TN-62, 1982: 29 pp.
Subject Codes: N/A
RCA: X1122

Five precommercial thinning case studies were undertaken to measure the efficiency of treatments as prescribed by cooperating foresters. These studies were located in the B.C. interior, on Vancouver Island and in Alberta. Data summaries provide stand conditions, procedures, hourly costs and productivity figures.

1224. JOHNSTONE, W.D. Heavy thinning accelerates growth of 77-year-old lodgepole pine. Forest Management Note No. 16, Northern Forest Research Centre, Edmonton, Alta., 1982: 3 pp.
7 ref.
Subject Codes: N/A
RCA: X1027

1225. JOHNSTONE, W.D. Precommercial thinning speeds growth and development of lodgepole pine: 25-year results.
Info. Rep., Northern Forest Research Ctre., Canada, 1981, NOR-X-237: v+30 pp.
21 ref.
Language: en
Summary Languages: fr
Subject Codes: 5.2
CAB: 1556526

Five plots of 22-yr. old fire-origin lodgepole pine in west-central Alberta were thinned to spacings between 1.5 x 1.5 m and 3.7 x 3.7 m; one of two 1.8 x 1.8 m plots was re-thinned to 70% b.a. after 15 years. Results are presented for: individual tree diameter and height; stand diameter, b.a., total and merchantable volume and survival; and crop-tree diameter, height, total and merchantable volume. Thinning improved individual tree growth, particularly diameter, with the greatest response at the widest spacing. Thinning also improved all per-ha stand measurements except b.a. Survival was greater on the thinned plots than on a control plot. All average and per-ha crop-tree measurements were greater for thinned stands. From author's summary.

1226. JOHNSTONE, W.D. 1985. Thinning lodgepole pine. Pages 253-262 in Lodgepole pine: the species and its management. Symposium proceedings. Pullman, WA.

This review paper summarizes, from a growth and yield perspective, North American thinning research on lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.), discusses some of the risks associated with thinning lodgepole pine, and highlights some current Canadian thinning practices.

1227. LYNCH, D.W. Mechanical thinning of young conifer stands.
Transactions of the ASAE (American Society of Agricultural Engineers), 1973, 16(1): 34-36
7 ref.
Subject Codes: N/A
CAB: 242110

Reviews literature on the mechanical thinning of dense and stagnating stands of young softwoods (particularly Pinus contorta) in the western USA, e.g. by bulldozing and/or crushing strips ca. 14 ft. wide, leaving intervening strips 4-15 ft. wide. It is concluded that this treatment shows promise as a first step in the rehabilitation of such stands. Mechanical and biological problems still unsolved are discussed.

1228. LYNCH, T.J. Thinning and spacing research in Sitka spruce and lodgepole pine.
IN: Growing Space in Coniferous Crops.
Irish Forestry, 1980, (37): 45-67
6 ref.
Subject Codes: 7.6.2
CAB: 1369087

The principal results of thinning and spacing studies in the Irish Republic are outlined. Increasing the spacing from 1.8 to 2.4 m2 in Sitka spruce results in an overall loss of production of about 4% (more in lodgepole pine) and corresponds to a thinning intensity that removed about 80% of volume increment over the rotation. The various methods of spacing and thinning are discussed, and a strategy is outlined for accelerated sawlog production by respacing (precommercial thinning) with special reference to lodgepole pine.

1229. PORTERFIELD, R.L., SCHWEITZER, D.L. A quick and data-poor approach to evaluating pre-commercial thinning.
Journal of Forestry, 1975, 73(12): 771-773
Subject Codes: N/A
CAB: 585031

1230. SMITHERS, L.A. Thinning in lodgepole pine stands in Alberta.
Canada, Dept. N.A. and N.R., For. Br., For. Res. Div., Tech. Note No. 52, 1957: 26 pp.
Subject Codes: N/A
RCA: X1035

1231. SORENSEN, J. Death by arsenic in Comox Valley.
British Columbia Lumberman, 1979, 63(8): 42-43
2 pl.
Subject Codes: 7.6
CAB: 1118674

Chemical thinning at Crown Zellerbach's Vancouver Island division utilizes MSMA (monosodium acid methanaersonate) to kill western hemlock, Douglas-fir, silver fir, lodgepole pine, ponderosa pine and western red cedar (Thuja plicata). It was less effective on alder. Tests on the workers showed a slight accumulation of arsenic after 5 days of work, but a 2-day break eliminated the residue.

## 7.8 FERTILIZING

1232. ALLEN, M.G. The effect of fertilizer on the growth of lodgepole pine Pinus contorta on oligotrophic lowland bog.
Phosphorus Agric., 1974, 28(62): 1-9
Subject Codes: 3.3
BIO: 75017273

1233. BARKER, P.R. Fertilizing and thinning in interior forests. E.P. 886.01. IN: Forest Research 1982-82
Ministry of Forests, Victoria, B.C., 1983: 53
Subject Codes: 7.7
RCA: X1061

1234. BEHAN, M.J. Fertilization in lodgepole pine forests.
Mont. Forest. Conserv., Exp. Sta. Note, Suppl. A(6), 1968: 1-3
Subject Codes: N/A
BIO: 70067700

1235. BELLA, I.E. Fertilizing after thinning 70-year-old lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) in Alberta.
N. For. Res. Centre, Edmonton, Alberta, Canada, Bi-monthly Research Notes, 1978, 34(4): 22-23
Subject Codes: 7.7
CAB: 1160907

Before thinning the stand had approx. 2500 stems/ha, and 33.4 m2/ha b.a. The thinning removed 66% of the stems and 55% of the b.a. N, P and S fertilizer was applied at three rates for each in an incomplete factorial pattern. Results suggest that thinning at this age is inadvisable because the remaining stand is liable to wind damage. There was no response to P or S. There was a response to N fertilizer mainly in the first 4 years after application, but this was probably not economic. The response to N was similar at 673 or 112 kg/ha.

1236. BENZIAN, B., BROWN, R.M., FREEMAN, S.C.R. Effect of late-season top- dressings of N (and K) applied to conifer transplants in the nursery on their survival and growth on British forest sites.
Forestry, 1974, 47(2): 153-184
27 ref. + 2 pl.
Subject Codes: 7.3
CAB: 471789

At two English forest nurseries (Wareham, Dorset, and Kennington, near Oxford), 1+0 plants of Picea sitchensis, P. abies, Tsuga heterophylla, Abies grandis and Pinus contorta were supplied with N, P, K, and MG, in amounts intended to produce healthy green trees with nutrient concentrations in the 'sufficiency range', as determined by earlier experiments. 'Luxury uptake' of N was obtained with top-dressings of 'Nitro- Chalk' applied during early Sept., when top growth had nearly ceased. The plants were lifted in Dec., kept in cold store during the winter and planted out in spring, in four successive years, at forest sites having a wide range of soil and climatic conditions in England, Scotland and Wales. N advanced bud-break in all species except A. grandis during the first summer after planting, and had no deleterious effect on survival. It tended to increase growth of P. sitchensis during the season after planting, but in later years the differences became small in relation to tree size. The effects on the other species were small, except for one considerable decrease in the growth response of A. grandis at a single site. Some experiments (confined to P. sitchensis) are described in which the effect of late-season applications of K on subsequent growth and survival in the forest was tested.

1237. BIGGS, W.L., DANIEL, T.W. Effects of nitrate ammonium and pH on the growth of conifer seedlings and their production of nitrate reductase.
Plant Soil, 1979, 50(2): 371-386
Subject Codes: 3.3
BIO: 68060393

Lodgepole pine (Pinus contorta Dougl.), Englemann spruce (Picea engelmanni Parry), and Douglas-fir (Pseudotsuga menziesii (Mirb.) seedlings were grown in open-ended tube cultures of sand and perlite, irrigated with NO3 NH4 and a 1:1 mixture of NH4 and NO3, combined factorially with pH values of 4.6, 5.3 and 6.0. Douglas-fir showed intolerance to NH4 which was especially marked in root weight. Lodgepole pine and Englemann spruce made poor growth with NO3, but showed little difference between NH4 and mixed sources. Only Douglas-fir showed a signficiant response to pH treatments with pH 5.3 plants being largest. Contamination of the sand with carbonate-bicarbonate, apparently caused seedlings grown in NH4 solutions to be larger in sand than in perlite. Douglas-fir grown in perlite cultures showed a growth response like the 1st experiment and NO3 reductase activity in the order NO3 greater than NO3 NH4 mixture greater than NH4. Plastic bead cultures had poor growth response due to low retention of water by the substrate, but the NO3 reductase assays produced results like the perlite cultures. Lodgepole pine grown in water culture demonstrated the well known pH shift associated with different N forms, and when assayed for NO3 reductase these seedlings had larger relative activities than Douglas-fir, but the order of activity remained NO3 greater than mixed source greater than NH4.

1238. BINNS, W.O., EVERARD, J., et al. Nutrition of forest crops, UK. IN: Report on Forest Research
Forestry Commission, UK, 1973: 50-60
5 ref. + 3 pl.
Subject Codes: 3.3
CAB: 451427

Describes the effect of N, P or K fertilizers on the growth of several conifers and on the concentration of foliar nutrients. Picea sitchensis on heathland soil was likely to be deficient in P after 5 years, and Pinus contorta grew less on northern hill peat when application of P was delayed after planting, but the growth of both species improved after fertilizer application. Applications of N to P. sitchensis in Sutherland were necessary after 6 years to maintain fast growth. Trees grown on ironpan soils did not shown nutrient deficiency but NPK treatment increased growth. May and July were the best times to apply K to P. sitchensis in Scotland. Details are given of the methods used for routine foliar analysis of increasing numbers of samples.

1239. BLACKMORE, D.G., CORNS, W.G. Lodgepole pine and white spruce establishment after glyphosate and fertilizer treatments of grassy cutover forest land.
Forestry Chronicle, 1979, 55(3): 102-105
7 ref.
Language: en
Summary Languages: fr
Subject Codes: 7.6.2
CAB: 1431627

The growth of one-year old plugs of Pinus contorta and Picea glauca on areas sprayed with glyphosate one day before planting was compared with that on unsprayed scalps and on control areas. Glyphosate was applied at 4.5 kg/ha in June or August with or without a 9 g NPK fertilizer tablet per seedling. The effects of glyphosate at 1.1-5.6 kg/ha on P. contorta in areas sprayed in August and planted in May were also investigated. For June plantings, growth of fertilized P. contorta on glyphosate strips was significantly greater than for all other treatments; growth of P. glauca was greatest on fertilized scalps. There was marked injury and mortality of P. contorta planted in August immediately after spraying, but those planted in May grew better than controls. In terms of vegetation control, glyphosate at 2.2 kg/ha applied in August was superior to 4.5 kg/ha applied in June.

1240. BOULLARD, B. Notes on forest biology. Late applications of fertilizer in nurseries and behaviour of plants after planting out in the forest.
Foret Privee Francaise, 1975, No. 103: 29-38
3 ref.
Language: fr
Subject Codes: 7.3
CAB: 525356

Reviews the conclusions of Benzian et al. in the UK regarding the beneficial effects of treating nursery stock of Picea sitchensis, P. abies, Tsuga heterophylla, Abies grandis and Pinus contorta with fertilizer (especially N) in early Sept. on the flushing, frost- hardiness and growth of the trees in their first year after planting out in the forest, and draws attention to the relevance of these results to French forestry.

1241. BOYD, W.C., STRAND, R.F. Nitrogen fertilization and chemical thinning of lodgepole pine stands on T.F.L. 9 (KE-5).
Crown Zellerbach Corp., Central Research Div., 1975: Res. Memo No. 624-2
Subject Codes: 7.6.2
RCA: X1156

1242. BRAEKKE, F.H. Boron deficiency in forest plantations on peatland in Norway.
Meddelelsar fra Norsk Institutt Skogforskning, 1979, 35(3): 213-236
47 ref.
Language: en
Summary Languages: no
Subject Codes: 3.3
CAB: 1358238

Effect of B fertilization was studied in plantations of Picea Abies, Pinus sylvestris, P. contorta ssp. latifolia and Betula spp. (especially pubescens) on 23 open, nutrient-poor, deep peatland sites in Norway. Sites were treated in spring 1977 with dosages ranging from 5 to 30 kg/ha borax. Content of B and other elements was determined in foliage collected in August/September of 1977 and 1978. Treatment with B eliminated shoot dieback and reduced frost damage effects (on height growth). Absolute B deficiency (less than 3 ppm) was found on inland sites, inside a coastal belt ranging from 20 to 60 km in breadth. Critical B levels to avoid growth disturbances when precipitation was normal were: 8-10 ppm for pine and spruce and 14-16 ppm for birch. Temporary B deficiency may occur during droughts. Optimal levels were: 20-25 ppm for Picea abies and Pinus sylvestris, 25-30 ppm for P. contorta and 28-33 ppm for Betula. A positive relationship was found between Mg and B uptake but not between that of Ca and B.

1243. COCHRAN, P.H. Temperature and soil fertility affect lodgepole and ponderosa pine seedling growth.
Forest Science, 1972, 18(2): 132-134

1 ref.
Subject Codes: N/A
CAB: 059857

The growth of Pinus contorta and P. ponderosa in the first season was measured in pots of AC-horizon pumice soil at four soil fertility levels, maintained at nine combinations of day and night temperatures. Results showed little difference between the species in their response to fertilizers or to low night temperatures (1 or 8 deg. C), and thus do not explain the relatively poor performance of P. ponderosa on these soils.

1244. COCHRAN, P.H. Response of pole-size lodgepole pine to fertilization.
USDA FOR. Serv. Res. Note, Pacific NW For. and Range Exp. Stn., 1975, No. PNW-247: 10 pp.
15 ref.
Subject Codes: N/A
CAB: 619194

Describes experiments in Oregon to determine the growth response of 40-year-old Pinus contorta trees to fertilizer treatment (N, P and S) from 1970 to 1974 after thinning in 1966-1967. Significant annual increases were noted in volume, b.a., bole area, and understory grass growth after treatment, and measurements of annual radial growth suggested that these increases would continue after the end of the 4-year study period. Height growth and uptake of soil water did not appear to be significantly influenced by the use of fertilizer, but sampling errors may have masked real differences in water uptake.

1245. COCHRAN, P.H. Response of thinned lodgepole pine after fertilization.
Research Note, Pac. NW For. and Range Exp. Stn., USDA For. Svce., 1979, No. PNW-335: 6 pp.
2 ref.
Subject Codes: 5.2, 7.7
CAB: 1514463

A further account of trials in Oregon. Significant increases in vol., b.a. and stem growth continued during the second 4-yr. period (1975-78) after initial application (in 1970) of N, P and S at 600, 300 and 90 lb/acre respectively. Ht. growth was also significantly increased although it had been n.s.d. during the first 4-yr. period. Grass production on fertilized plots continued to be higher than on control plots.

1246. COCHRAN, P.H., YOUNGBERG, C.T., et al. Response of ponderosa pine and lodgepole pine to fertilization.
IN: Proceedings of the Forest Fertilization Conf., 1979, Sept. 25-27, Seattle,WA.
Subject Codes: N/A
RCA: X1207

1247. DRAPER, D.A. Introducing nitrogen into a young pl stand: A comparison of methods. E.P. 886.02. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 53
Subject Codes: N/A
RCA: X1062

1248. FRYK, J. Svalmyren, a drainage and fertilizer trial.
Skogen, 1978, No. 3: 33-34
1 pl.
Language: sv
Subject Codes: 7.4
CAB: 928068

Ten-year results are given from a trial in Halsingland, Sweden, in which a Pinus contorta provenance from Karr Lake, Alberta, a local Pinus sylvestris provenance and a Picea abies provenance from Lithuania were planted on a bog site after draining and fertilizing with PK or NPK. The survival rate of P. contorta was 70% vs 50% for P. sylvestris; P. abies was a failure. Response to fertilizing was better for P. contorta than for P. sylvestris. In both cases, NPK gave a better height growth than PK; this was still noticeable after 10 years. Initially P. contorta responded more slowly but exceeded P. sylvestris in height growth after 2 to 3 years and increased its lead to the end of the period.

1249. HOCKING, D. Comparison of proprietary with prescription nutrient solutions for Alberta white spruce and lodgepole pine.
Info. Report, Northern For. Res. Centre, Canada, 1972, No. NOR-X-35: 19 pp. 2 ref.
Subject Codes: 3.3
CAB: 106072

The nutrient solution for seedling culture previously described proved superior to three proprietary fertilizers in a 10-16 week laboratory trial on seedlings of Picea glauca var. albertiana and Pinus contorta var. latifolia.

1250. LANDIS, T.D. Nitrogen fertilizer injures pine seedlings in Rocky Mountain nursery.
Tree Planters' Notes, 1976, 27(4): 29-32, 35
4 ref.
Subject Codes: 6.5
CAB: 928078

Chlorosis and dwarfing of seedlings of lodgepole pine (Pinus contorta var. latifolia) were caused by high concentrations of N from rapid release fertilizer ($NH_4NO_3$) applied to cool, heavy soils in Carbondale, Colorado. From author's summary.

1251. LOW, A.J., SHARPE, A.L. The long term effects of organic and inorganic fertiliser regimes at Teindland nursery.
Scottish Forestry, 1973, 27(4): 287-295
4 ref.
Subject Codes: 7.3
CAB: 234893

Contrasting fertilizer regimes based on hop waste only, inorganic fertilizers only, or a combination of the two, were used annually, over a 20-year period, to raise Pinus contorta and Picea sitchensis seedlings from seed in a heathland nursery in Morayshire. In most seasons, all three regimes gave satisfactory seedling growth and yield. The findings agree with results of comparable trials in the south of England and showed no evidence of a decline in seedling quality caused by repeated annual use of inorganic fertilizers.

1252. MCINTOSH, R. Effect of different forms and rates of nitrogen fertilizer on the growth of lodgepole pine Pinus-contorta.
Forestry (OXF), 1982, 55(1): 61-68
Subject Codes: 2.5, 3.3
BIO: 74082891

Application of 4 forms of N fertilizer each at 3 rates produced significant positive responses in shoot growth in a 7-yr-old P. contorta, Dougl. stand on a deep, infertile peat in south Scotland. The response was short-lived (4 yr) and was followed by a period (1-2 yr) when shoot growth fell below the control level. Form of N did not affect the result but rate of N did and these effects are discussed with respect to annual shoot growth, foliar N levels and shoot growth: foliar N correlations.

1253. MELLOR, G.E., TREGUNNA, E.B. The relationship between leaf area and leaf dry weight of 3 conifer species grown on 3 sources of nitrogen.
Can. J. For. Res., 1972, 2(3): 377-379
Subject Codes: 3.3, 5.6
BIO: 55025535

1254. MESHECHOK, B. On starting fertilization for the afforestation of moors in Norway.
IN: Proceedings of the Colloquium of the International Potash Inst., Vol. 5, Colloquium on Forest Fertilization. 379 pp.
International Potash Inst., Berne, Switzerland, 1967: 282-290
Subject Codes: 3.3, 7.4.1
BIO: 71001298

1255. O'CARROLL, N. Forest fertilization in the Republic of Ireland. IN: Proceedings of the Colloquium of the International Potash Inst., Vol. 5. Colloquium of

Forest Fertilization, 379 pp.
International Potash Inst., Berne, Switzerland, 1967: 271-274
Subject Codes: N/A
BIO: 71001296

1256. SAVILL, P.S. Fertilizer requirements of lodgepole pine at time of planting on oligotrophic peat.
Forester, Belfast, UK, 1976, 15(2): 36-37
Subject Codes: N/A
CAB: 734976

Lodgepole pines (Pinus contorta) planted in 1972 and 1973 on oliogotrophic peat in 4 sites in N. Ireland, were treated with combinations of different rates of CRP (coarse rock phosphate), muriate of potash and urea. Measurements at the end of the 1975 growing season indicated a growth increase of 40% with application of potash. Application of 500 kg/ha CRP and 200 kg/ha muriate of potash are recommended at the time of planting.

1257. SHLEINIS, R.I., RAGUOTIS, A.D. Diagnosis of mineral nutrition and fertilization of pine stands of the southern Baltic region.
Lithuanian Forest Research Institute. Vil'nius 1976: 44 pp.
Languages: ru
Summary Languages:
Subject Codes: 3.3
RCA: X1001

1258. VAN DEN DRIESSCHE, R. Fertilizer experiments in conifer nurseries of British Columbia.
Research Note, British Columbia Forest Service, 1977, No. 79: iv + 32 pp.
29 ref.
Subject Codes: 7.3
CAB: 914706

Three experiments were conducted: (a) NPK was applied to Pinus contorta in a factorial design in the first and second years after planting. N had the most significant effect on growth; dry weight per unit length of shoot was greatest for seedlings given the most N in the second year rather than the first year. Recommended applications in kg/ha are 80 N, 135 P before sowing, 40 K during the first year and 120 N, 90 K during the second year. Chemical analysis of 2 + 0 seedlings showed that shoot dry weight incrased as foliar Ca concentration decreased. Expected macronutrient concentrations are given for healthy P. contorta. (b) Five rates of K were applied to Pseudotsuga menziesii and Picea glauca either before sowing or as single, double or triple top dressings after germination; top dressings were repeated in the following year. Pre-sowing applications increased dry weight slightly to a maximum at 180 kg/ha K. Maximum dry weight for top-dressing treatments occurred at lower rates; with triple top-dressings the maximum occurred at 22 to 45 kg/ha. Dry weight of Pseudotsuga menziesii was correlated with % K in the tissues. (c) Three rates of P (applied as calcium superphosphate) and 2 rates each of Fe, Cu, Zn, Mn, Mo and B were applied to Picea glauca in the first and second years after sowing. The micronutrients did not significantly affect seedling growth. Growth responses to P were not consistent, but seedling density decreased with higher P applications.

1259. WEETMAN, G.F., FOURNIER, R.F. Forest fertilization screening trials, interior of British Columbia, 1980. Lodgepole pine, Douglas-fir and white spruce.
Report of the B.C. Forest Service , 1981, FS-92: 387 pp.
Subject Codes: N/A
RCA: X1136

1260. WEETMAN, G.F., FOURNIER, R.F. Graphical diagnosis of lodgepole pine response to fertilization.
Soil Science Society of America Journal, 1982, 46(6):1280-1289
Subject Codes: N/A
RCA: X1137

1261. WEETMAN, G.F., FOURNIER, R. Fertilizer screening trials in the interior of B.C. E.P. 884. IN: Forest Research Review 1981-82.

Ministry of Forests, Victoria, B.C., 1983: 52
Subject Codes: 3.3
RCA: X1060

1262. WEETMAN,G.F., YANG, R.C., BELLA, I.E. 1985. Nutrition and fertilization of lodgepole pine. Pages 225-232 in Lodgepole pine: the species and its management. Washington State University, Pullman, WA.

Lodgepole pine is not considered to be a nutrient demanding species. It grows well on nutrient poor soils. A review of the relatively few fertilization trials in North America is presented. Fertilizer work in both jack pine and lodgepole pine suggests a close similarity in response between the species, which actually interbreed. Lodgepole pine appears to be particularly responsive to nitrogen additions; phosphorus deficiencies may be induced by nitrogen additions. Responses as high as 50% in volume increment over a 10-year period have been found with applications of nitrogen over 150 kg/ha. Some case study data are presented. In North America most fertilization studies have been conducted in naturally regenerated stands on upland sites, often following spacing. Boron and copper micronutrient deficiencies have been identified on some soils. In Europe, particularly in Ireland, phosphorus and nitrogen are required in the extensive use of coastal lodgepole pine in peatland afforestation.

1263. WILL, G.M. The occurrence and treatment of boron deficiency in New Zealand pine forests.
New Zealand Forest Serv. Res. Leaflet 32, 1971: 1-4
Subject Codes: N/A
BIO: 71052599

1264. YANG, R.C. 1985. Ten-year growth response of 70-year-old lodgepole pine to fertilization in Alberta. Information Report, Northern Forestry Research Center, No. NOR-X-266. 17 p.

Stands on 2 sites were treated in May 1972 with combinations of 0, 76, 188, 300 or 377 kg/ha N, 0, 38, 94, 150 or 188 kg/ha P, and 0, 23, 56, 90 or 113 kg/ha S. Soil and foliar samples were analysed in Autumn 1971, 1972 and 1973. D.B.H. was recorded in Autumn 1971 Summer 1981, and sample trees were felled for stem analysis. After 10 yr, the most productive plots had increased total and merchantable vol. by 31-34 and 28-33 m3/ha respectively, representing increases of up to 50% in periodic vol. increment. The most significant response was produced by at least 188 kg/ha N. The addition of 38-94 kg/ha P improved vol increment on one site. The effect of S was inconclusive.

1265. YANG, R.C. 1985. Effects of fertilization on growth of 30-year-old lodgepole pine in west-central Alberta. Information Report, Northern Forestry Research Center. No. NOR-X-268. 11 p.

Nitrogen, P and S were applied to two 30-yr-old stands of lodgepole pine of fire origin on mercoal and coalspur soils. Results 10 years after fertilization showed that, on coalspur soils, N improved tree diam. and vol. increment for treatments in both factorial series. On mercoal soils, fertilization effects were significant in only one factorial series where N + S improved tree vol. increment, but only S improved diam. increment. The effects of N and S on stand vol. increment were not significant because of increased and variable mortality. It is suggested that thinning should precede fertilization of dense stands. The effects of P were not significant.

## 7.9 PRUNING

1266. ANON. Chemical root pruning trial with lodgepole pine (SX 812112Q). IN: Forest Research 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 119-120
Subject Codes: N/A

RCA: X1071

1267. BURDETT, A.N. Box-pruning the roots of container grown tree seedlings. IN: Proc. Canadian Containerized Tree Seedling Symp.
Toronto, Ont., Sept. 14-16, 1981
Subject Codes: N/A
RCA: X1049

1268. BURDETT, A.N. Chemical control of root morphogenesis in container seedlings. E.P. 791. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 25
Subject Codes: N/A
RCA: X1047

1269. BURDETT, A.N., MARTIN, P.A.F. Chemical root pruning of coniferous seedlings.
Hortscience, 1982, 17(4): 622-624
Subject Codes: 7.4.4
BIO: 75010180

Conifer seedlings of 10 spp. from 6 genera (Abies amabilis, Picea glauca, P. sitchensis, Pinus contorta, P. monticola, P. ponderosa, P. sylvestris, Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla) were raised in containers coated on the inside with basic cupric carbonate in latex paint. The copper paint prevented lateral roots from growing down or around the container wall. After transplanting, the chemically root-pruned stock was capable, in most cases, of vigorous root growth. The effectiveness of the chemical root pruning treatment varied with species, container size, growing medium, and the concentration of cupric carbonate in the container wall coating. Three conifer species, Pinus contorta Dougl., Pinus flexilis James and Picea engelmannii Parry, were inoculated with the ectomycorrhizal fungi Pisolithus tinctorius (Pers.) Coker et Couch, Suillus granulatus (L. ex Fr.) Kuntze and Cenococcum geophilum Fr. These, plus noninoculated control seedlings, were grown in a greenhouse for 8 mo. to assess mycorrhizal formation and seedling response. For all conifer species, top height, diameter and seedling total dry weight were greater in the S. granulatus and control (wild fungus) treatments as compared with P. tinctorius and C. geophilum. In the 2nd year of the study, greenhouse container-grown conifers with ectomycorrhizae formed by the above 3 fungi and an unknown fungus were planted under 4 fertilizer treatments on a high-elevation (3200 m) molybdenum tailing pond covered with deep mine waste rock. After 4 yr in the field, height growth of the seedlings (all tree species combined) inoculated with S. granulatus were greater than seedlings inoculated with P. tinctorius, C. geophilum or control (wild fungus). Through growing seasons, a sewage sludge and wood-chip treatment resulted in greater height growth than the 3 treatments of combined inorganic N and P, P alone and no fertilization. The combined survival for all species and all treatments was 58% after 4 growing seasons.

1270. DYKSTRA, G.F. Undercutting depth may affect root-regeneration of Lodgepole pine seedlings.
Tree Planters' Notes, 1974, 25(1): 21-22
2 ref.
Subject Codes: 2.3, 7.3
CAB: 304921

Seedlings of Pinus contorta var. latifolia, 6 weeks old, were undercut 3, 6 or 12" below the root-collar and harvested two months later. Significant differences were found in taproot growth. Seedlings undercut at the 3" depth showed the most growth in length and dry weight of the taproot, and the greatest total dry weight of roots (including the dry weight removed by undercutting). There were significant differences between the treatments in the dry weight of 3" sections of root below a depth of 9".

1271. SIMPSON, D.G. Effects of antitranspirants on storability, drought resistance, and field performance of conifer seedlings. E.P. 827.04. IN: Forest Research Review 1981-82.
Ministry of Forests, Victoria, B.C., 1983: 28
Subject Codes: N/A
RCA: X1048

## 8.0 FOREST MANAGEMENT

1272. ANON. The lodgepole pine improvement program.
B.C. Ministry of Forests, 1978: Res. Memo No. 33
Subject Codes: N/A
RCA: X1173

1273. ALEXANDER, R.R. Multiresource management of subalpine and montane forests.
Project RM-1252, Rocky Mountain For. and Range Exp. Stn., Fort Collins, COL, 06 Dec 79 to 30 Nov 84
Subject Codes: N/A
CRIS: 0045931

Objectives: To facilitate decision-making in multi-resource management of subalpine and montane forests in the central Rocky Mountains. Approach: Field research will focus on the interactions of timber management systems with wildfire and water values; recreational development with wildfire and water values; and economic, social and environmental impacts of destructive insect pests. Improved models will be developed for prediction of growth and yield for common timber species. Better tools will be developed for predicting multi-resource interaction by synthesis of past and new research. Progress: Domestic, agricultural and industrial demand for water yielded from the Rocky Mountains has increased significantly, and supplies are limited. From 70 to more than 90 percent of the total annual flow from alpine and subalpine watersheds come from melting snow and occurs during a 60 to 90 day period in late spring to early summer. Research has led to improved management of the deposition and redistribution patterns of the snow pack as well as the control of its melt rate, which can result from both vegetative manipulation and physical structures such as snow fences and other forms of man-made roughness. Although its effect on water yield has not been quantified, ability to control the placement of blowing snow using vegetation, fences, and other forms of roughness greatly reduces sublimation loss from airborne snow particles and, because of the piling effect, retards the melt rate. Harvesting subalpine timber in small patches causes greater accumulation of snow in the openings and results in an increased efficiency in delivering the melt water to the stream channel system. Moreover, the effect of such vegetation manipulation on streamflow persists relatively unaltered for 20 years or more.

1274. ALEXANDER, R.R. Silviculture of subalpine forests in the central and southern Rocky Mountains: the status of our knowledge.
USDA For. Serv. Research Paper, Rocky Mountain For. and Range Exp. Stn., 1974, No. RM-121: 88 pp.
10 pp. of ref.
Subject Codes: 7.0
CAB: 409281

Deals with the spruce/fir and lodgepole pine forest types. In addition to the sections common to this series of reports, the properties and uses of the wood of Picea engelmannii, Abies lasiocarpa and Pinus contorta are briefly discussed and recommendations are made for the management of young-growth P. contorta.

1275. ALEXANDER, R.R., EDMINSTER, C.B. Lodgepole pine management in the central Rocky Mountains.
J. For., 1980, 78(4): 196-201
Subject Codes: 3.7, 7.7
LISC: 495154

Estimates obtained by simulation are given for potential production of lodgepole pine (Pinus contorta) in the central Rocky Mountains under various combinations of stand density, site quality, ages, and thinning schedules. Such estimates are needed to project future development of stands managed for various uses.

1276. ALEXANDER, R.R., EDMINSTER, C.B. Management of lodgepole pine in even aged in the central Rocky Mountains.

Research Paper, Rocky Mtn. For. and Range Experiment Station, USDA For. Service, 1981, No. RM-229: 11 pp.
1 pl.
Subject Codes: 5.1, 5.2
CAB: 1487383

A supplement to a previous paper including extra graphical, tabular and descriptive information. From authors' summary.

1277. ANDREASON, O. Future forest management trends in Sweden.
Forestry Chronicle, 1978, 54(1): 29-33
1 pl.
Language: en
Summary Languages: fr
Subject Codes: 7.0, 7.1, 7.3, 7.4, 7.6
CAB: 1233100

Measures that are being adopted to improve the annual production in Sweden include; an increase in the application of fertilizers, artificial regeneration, mechanization, stump harvesting and use of container-grown planting stock. The drainage of wet lands and the planting of lodgepole pine on poor sites in the N. and Norway Spruce in the S. are also in progress.

1278. BAUMGARTNER, D.M. (Editor), LOTAN, J.E., SWEET, D.C. Management of lodgepole pine ecosystems.
Washington, USA, Washington State University Extension Service, 1975: v + 882 pp.
many ref.
Subject Codes: N/A
CAB: 676847

A collection of 38 papers (in two volumes) presented at a symposium held at Washington State University, Pullman, Washington from Oct. 9-11, 1973. Papers relate to the principal scientific, technological and economic aspects of managing Pinus contorta ecosystems. The publication also includes: A partially annotated bibliography of lodgepole pine literature 1954-1973 (J.E. Lotan and D.C. Sweet; 1155 ref.); in which entries are classified according to the Oxford System of Decimal Classification for forestry.

1279. BOTTOMS, K.E., BARTLETT, E.T. Resource allocation through goal programming.
Journal of Range Management, 1975, 28(6): 442-447
10 ref.
Subject Codes: N/A
CAB: 677010

Discusses this technique in comparison with linear programming, and describes an application to the multiple-use management of 9050 acres of land above 8500 ft alt. in the Colorado State forest consisting of spruce/fir forest, Pinus contorta forest, Willow carrs, and three open cover types. For each cover type, yields of multiple resources ulated for several management alternatives (clear felling, patch logging, aerial spraying, etc.) Over-all solutions are tabulated for four optimum programmes determined by various priorities with regard to total profit, recreation user days, and budgeted expenditure.

1280. COLE, D.M. Culture of immature lodgepole pine stands for timber objectives. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 536-555
29 ref.
Subject Codes: 7.0, 8.5
CAB: 757614

A review of management practices for controlling growing stock in established immature Pinus contorta stands. These include precommercial thinning, commercial thinning repeated at 20-year intervals, and stand amendment. Growth projection simulation studies successfully predicted actual growth after precommercial thinning of stagnating, overstocked stands in Montana and Idaho. Maximum m.a.i. was the main criterion for assessing stocking and the effects of thinning. Results indicated that the total volume produced at rotation age may exceed that from natural stands not considered to be stagnating. Methods of precommercial

thinning are discussed. Except for stagnating stands, repeated thinnings did not increase overall growth. The major growth-increasing effect of repeated thinnings in stagnating stands probably comes from the first thinning. The possible increase in populations of Dendroctonus ponderosae due to the increased number of large diameter, thick phloem trees produced by repeated thinnings is briefly considered.

1281. COLE, D.M. 1983. Canopy development in lodgepole pine: implications for wildlife studies and multiple resource management. General Technical Report, Intermountain Forest and Range Experimental Station, U.S.D.A. Forest Service. No. INT-139. 13 p.

A discussion of the use of computer simulation models of vertical crown development in studies of relations between wildlife and forest cover. These models can be linked with stand projection programs to illustrate the effects of varying timber management prescriptions on components important to wildlife--such as height to canopy, canopy depth, stand height, and canopy coverage. Examples are given of the results of 5 management prescriptions applied to 5 initial stand densities in Montana and Idaho from age 20 to 140 yr at 10 yr intervals.

1282. CROSSLEY, D.I. Forest management by North Western Pulp and Power based on lodgepole pine and spruce forest.
Can. For. Serv. For. Manage. Inst., Info. Rep., FMR-X(103); 1978
Subject Codes: N/A
BIO: 16038088

1283. FLEWELLING, J.W., DREW, T.J. 1985. A stand density management diagram for lodgepole pine. Pages 237-244 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Stand density is the primary factor controlling growth and development of managed even-age stands. A stand density management diagram is a graphical device which focuses attention on this relationship. Age and site are not emphasized. Growth and mortality data from managed stands of Pinus contorta Dougl. in Oregon, British Columbia, Alberta, Finland, Sweden, United Kingdom and New Zealand was kindly provided by government agencies. This data was used in developing a common prediction equation for gross volume increment. this equation predicts that sixty percent of the maximum growth per unit area can be achieved at densities of about one-fourth the maximum. The same data was used to position mortality trend lines on the diagram.

1284. HAGNER, S.O.A. 1985. Lodgepole pine management in Sweden: a strategy for higher yield. Pages 211-217 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Small plantations of Pinus contorta Dougl. were established in Sweden in the 1920s. commercial planting started at the end of the sixties. Since then more than 200,000 ha (over 500,000 acres) of lodgepolepforest have been established. The plantations are of the inland variety Pinus contorta var. latifolia Engelm. form northern British Columbia and the Yukon Territory. Pinus contorta is an interesting species from the point of view of Sweden's intensive forestry. The properties of its wood resemble those of the native pine Pinus sylvestris L., but it grows 60-80 percent faster. the lodgepole pine is easy to cultivate, it is hardier than the native pine in regions of severe climate, and it is more resistant to infestation, It appears to be well suited for genetic improvement. The establishment of large-scale plantations of lodgepole pine creates a substantial timber reserve that will soon be ripe for harvesting. Rotation can be accelerated in the older parts of the existing forest, and the cut can be increased. Svenska Cellulosa Aktiebolaget (SCA) has planted 140,000 ha (350,000 acres) of lodgepole pine over a 10-year period, and this has allowed the company to increase the cut from its forests by about 300,000 m3 (10 million cu.ft) per annum. The stand management program aims at a short rotation period of 45-60 years with little or no thinning. Transplantation of a tree species into a new environment calls for careful scientific backup. It must be determined whether the tree can thrive and fit into its new home. For trees with a wide geographical distribution like lodgepole pine, provenance experiments are an essential element. How well the tree withstands pathogens and other attacks can only be determined after a period of actual cultivation.

The cultivation of the lodgepole pine in Sweden is an example of how the methodical introduction of an exotic species can be implemented.

1285. HALL, F. 1985. Stockability and management of lodgepole pine using growth basal area. Pages 245-252 in Lodgepole pine: the species and its management. Symposium proceedings. Pullman, WA.

Stockability of pure, even-aged lodgepole pine is evaluated using growth basal area (GBA). GBA is the basal area at which dominant trees grow at the rate of 25 mm in diameter per decade. GBA is determined on site by relating current diameter growth rate to a curve for conversion to 25 mm diameter growth and applying a conversion factor to current basal area to obtain GBA. The USDA, Forest Service Ecology Program in Oregon and Washington has found more than GBA for a lodgepole pine site index (SI) class (base age 50). SI 9 m can have GBA's of 11, 24 and 40 m2 per hectare. SI 15 m can have GBA's of 22, 39, and 46 m2 per hectare. GBA class 23 m2 can occur in both SI 9 m and 15 m and GBA class 39 m2 can also occur in SI 9 m and 15 m. SI is not a suitable index for estimating stockability. The GBA concept is applied in this paper to prescribing number of residual trees per hectare following pre-commercial thinning for two management objectives: (1) Clearcut when trees reach 25 cm dbh and a diameter growth rate of 20 mm per decade and (2) commercially thin at 20 cm DBH and 30 mm diameter growth per decade. For example, residual trees per hectare for clearcutting and the corresponding crown competition factor (CCF) at harvest are: GBA 11 m2 at 260 TPHa and CCF 87, GBA 23 m2 at 505 TPHa and CCF 109, GBA 39 m2 at 864 TPHa and CCF 150, and GBA 46 m2 at 1015 TPHa and CCF 168. GBA, a function of diameter growth and basal area, is a useful tool for estimating stockability of a site.

1286. HAMRE, V. Management for multiple use. IN: Management of Lodgepole pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 651-657
Subject Codes: 8.7, 8.8
CAB: 757878

Briefly reviews the scientific, technological, economic, social and political aspects and in particular, the influence of the public on multiple-use management of Pinus contorta ecosystems.

1287. JOHNSON, R. 1985. Stocking guide for lodgpole pine using the Stand Prognosis model. Pages 231-238 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Conventional stand stocking guides can be constructed using forest inventories and a growth and yield model. An example stocking guide is presented for a group of forest habitat types found east of the Continental Divide in Montana. Forest inventory samples are used to establish maximum density and provide data for simulations. Results of thinning simulations are used to establish minimum stocking levels. Only even-aged sample stands are desired from the forest inventory samples. Difficulties presented by stagnation, residual overstories, and advanced reproduction are discussed.

1288. KALUTSKII, K.K., KRYLOV, G.V., BOLOTOV, N.A. Prospects for the introduction of tree species when creating forests of the future.
Lesnoe Khozyaistvo, 1981, (No. 11): 22-25
8 ref.
Language: ru
Subject Codes: 1.5, 8.1
CAB: 1539455

A general review is given of the history of exotics in forestry in the USSR, with details of the more promising species and the regions where they can be profitably used. The promising species include Larix decidua (Sudeten and Polish ecotypes), L. X eurolepis, Pseudotsuga menziesii, Pinus contorta (var. murrayana), Thuja plicata, and Quercus rubra.

1289. KREBILL, R.G., HOFF, R., BELLA, I. 1985. Symposium field tours: observations on lodgepole pine forestry in North America. In Lodgepole pine: the species and its management. Symposium proceedings. Washington State University,

Pullman, WA.
This report contains observations from symposium field tours to see genetic variation of lodgepole pine at the Priest River Experimental Forest (PREF) in northern Idaho, lodgepole pine forestry in mixed conifer forests of northeastern Washington, and research and management in the heartland of lodgepole pine, near Hinton, Alberta.

1290. LINES, R. 1985. Lodgepole pine management in the United Kingdom pages 219-224 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Conifer High Forest in Britain covers 1,375,000 hectares, all plantations except for 10,500 ha of native Scots pines. Nearly half of the Forestry Commission area is planted with Sitka spruce; lodgepole pine (12.1%) has the next largest area (101,391 ha). In Northern Ireland pure lodgepole pine in British privately owned forests is 26,677 ha. It was planted in forest trials from 1912, but on a small scale until 1947. The oldest experiment dates from 1921. Since then over 400 experiments have used lodgepole pine, including 83 provenance trials with 340 seedlots. On fertile sites many species are more productive, so its use is confined to infertile sites, exposed uplands and sites with air pollution or salt spray. High genetic variability and use of inferior seed origins led to many management problems: instability, snow damage, slow growth, poor form, exposure damage, susceptibility to disease and pests. It was used on a wide scale in mixture with sitka spruce in the 1950s and early 1960s. the results were often disappointing, due to incorrect choice of origin. Recently, an important nursing effect on spruce has been shown when Alaskan origins are used. Nutritional regimes for different seed origins and site types are now quite well established. Suitable thinning regimes on sites with a low windthrow hazard are also known, though on many other sites a 'no thinning' policy is now adopted. Natural regeneration can be copious, as the serotinous habit is largely unknown under British conditions. However, pioneer crops of lodgepole pine may be replaced by more productive species in the next rotation.

1291. MCDOUGALL, F.W. The importance of lodgepole pine in Canada. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 10-25
10 ref.
Subject Codes: 8.1, 8.8
CAB: 757521

Pinus contorta occurs commonly in western Canada as a major component of the forest cover in relation to the main mountain catchments: forests composed predominantly of P. contorta occupy 50 million acres. Its role in recreation areas, as a wildlife habitat and as a source of timber are discussed.

1292. REED, F.L.C., BASKERVILLE, G., et al Forest management in Canada. Volume II. Case studies.
Info. Rep., For. Management Inst., Canada, 1978, No. FMR-X-103: xxix + 176 pp.
88 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 950397

Five case studies supplementing (and summarized in) Volume I by illustrating management costs, benefits and difficulties in specific situations: Baskerville, G.; Weetman, G.F. Forest management at Nova Scotia Forest Industries Ltd. (4 ref.) Based on fir/spruce (Abies balsamea/Picea spp.). Armson, K.A. Management of jack pine species: with special attention to the Englehart Unit in Ontario. (29 ref.) Pinus banksiana. Crossley, D.I. Forest management by North Western Pulp and Power Ltd. (8 ref.) Based on lodgepole pine (Pinus contorta) and spruce (Picea spp.) forest in W. central Alberta. Smith, J.H.G. Management of Douglas-fir and other forest types in the Vancouver Public Sustained Yield Unit. (11 ref.) With details of an inventory made in 1970 and local yield data for Pseudotsuga menziesii, Tsuga heterophylla and Thuja plicata. Armson, K.A.; Smith, J.H.G. Management of hybrid poplar, (36 ref.) A general survey of poplar (Populus spp., all sections) growing and hybrid poplar trials throughout Canada.

1293. SCHMIDT, W.C., ALEXANDER, R.R. 1985. Strategies for managing lodgepole pine Pages 201-210 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Lodgepole pine (pinus contorta Dougl.) is an aggressive pioneer species that is well adapted to regenerating sites disturbed by fire, harvesting, or other disturbances. It is a seral species that most commonly grows in pure or nearly pure, even-aged, single storied, overly dense stands. However, it also grows in association with a wide variety of both seral and climax species. Because of rapid juvenile growth, it overtops most of its associates for about the first 50 years. Lodgepole pine is usually easy to regenerate naturally or artificially. It is a prolific seed producer with good crops every 1 to 3 years--serotinous and nonserotinous cones are common throughout much of its range. Serotinous cones provide abundant seed on cutover or burned areas. Nonserotinous cones can disperse enough seed to restock sites within about 60 meters (200 feet) from timber edge. Mineral soil seedbeds are best for lodgepole pine establishment and development. Lodgepole pine is best managed using even-aged silvicultural systems-- clearcutting is the most commonly used method. Seed tree cutting is not appropriate because residual trees are easily windthrown. Shelterwoods can be used where windthrow is not a problem and additional shade is needed for regeneration establishment. Group selection is the only appropriate uneven-aged cutting method, and then only where management objectives dictate the need for a variety of age classes in a relatively small area.

1294. U.S.D.A. FOREST SERV. National forest landscape management. Volume 2, chapter Timber.
Agriculture Handbook, USDA, 1980, No. 559: iv + 223 pp.
17 ref., 139 col. pl.
Subject Codes: N/A
CAB: 1487655

Volume 1 and Volume 2, Chapters 1-4 are available respectively as Agriculture Handbooks 434, 462, 478, 484, and 483. A comprehensive guide with 11 sections, including 6 on planning and managing the harvesting and regeneration of ponderosa and lodgepole pines, southern spruce/western hemlock, according to 5 different visual quality objectives (preservation, retention or partial retention, and modification or maximum modification) and 2 short-term management alternatives (enhancement or rehabilitation).

1295. WALTERS, R.M., BACON, W.R., TWOMBLY, A.D. Timber management simulated field trip, Gen. Tech. Report, Pacific SW For. & Range Experiment Stn., 1979, No. PSW- 35: 36-43
9 ref., 7 pl.
Subject Codes: 2.0, 7.0
CAB: 1233591

Visual and silvical characteristics of stands of ponderosa and lodgepole pines and Douglas-fir are described with the aid of photographs. Management opportunities for production of visually acceptable stands are outlined.

1296. WELLNER, C.A. The importance of lodgepole pine in the United States. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 1-9
8 ref.
Subject Codes: 8.8
CAB: 757520

In range, acreage and volume, Pinus contorta is an important species in western USA. Its reproductive ability and rapid juvenile growth rate increase its value as a pulpwood species and as a nurse crop. It is an important timber species, a major tree cover in scenic and recreational areas and provides cover for livestock and wildlife.

1297. WILLIAMS, D.H., YAMADA, M.M. A clustering technique for land management models.

Canadian Journal of Forest Research, 1976, 6(4): 532-538
13 ref.
Language: en
Summary Languages: fr
Subject Codes: 8.4
CAB: 747037

A hierarchical form of cluster analysis was used in a mathematical programme to group land units into a specified number of clusters with maximum similarity of the land units within each cluster. The use of the analysis is demonstrated for creating Timber RAM timber classes for a forest in British Columbia. The use of the technique to cluster data within subsets is also described, and an example is given, in which lodgepole pine (Pinus contorta) types are segregated from other forest types in Timber RAM, when accelerated felling of mature stands is prescribed to control beetle infestations.

## 8.1 HISTORY, UTILIZATION

1298. BARTLETT, E.T. Timber and forage interrelationships in western montane forests.
Project COL00214, Colorado State Univ., Fort Collins, COL, 01 Oct 79 to 30 Sep 84
Subject Codes: 8.8.5
CRIS: 0079895

Objectives: Identify and quantify biotic and abiotic factors important to timber and forage production in Rocky Mountain aspen forests, identify and quantify the relationships between timber and forage production in lodgepole and ponderosa pine forests in Colorado's Front Range, develop simulation models that will be useful in making resource allocation decisions, and that will be based on measurements available to land management agencies, and apply these models in actual land use planning efforts of cooperating agencies. Approach: Evaluation and collation of previous studies that are related to the identification and quantification of interrelationships between timber and forage production in western montana forests; and, use previous studies of the two forest ecosystems (e.g., lodgepole and ponderosa pine forests) and past modeling investigations as a point of departure. Mechanistics and descriptive simulation models will be developed to describe the joint production of timber and forage production. Progress: Past research relating understory parameters to overstory parameters has been reviewed for lodgepole pine and ponderosa pine montana forests. The review for lodgepole pine applied to all regions, while the review for ponderosa was limited to the Central Rocky Mountains. The studies are being compared with respect to consistency between studies and reasons for variations between studies. Each study is being evaluated as to the type of relationship presented between forage and timber, the dependent and independent variables used, the availability of information on variables in the field, and economic analyses.

1299. BENSON, R.E., STRONG, R.A. Wood product potential in mature lodgepole pine stands, Bitterroot National Forest.
Res. Pap., USDA For. Serv., Intermountain For. and Range Exp. Stn., 1977, INT-194: 16 pp.
Subject Codes: 2.0, 5.2
LISC: 059589

Volume and characteristics of woods in mature lodgepole pine stands in the Bitterroot National Forest, Montana, are presented. Growth is low and deadwood volumes are high in these stands, but 75% of the total volume of these stands is suited for high value products such as houselogs, posts and poles.

1300. BENTLEY, J.E. 1985. The future of lodgepole pine forestry--a private manager's perspective in the USA. Pages 355-357 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Because of the increased number of stud mills built in the 1960's, industrial forest managers began to see more opportunities to convert mature lodgepole pine stands to new stands. Lodgepole pine forestry exhibits some comparative advantages across the entire spectrum of its management to include seed production, regeneration, growth, and end use. Lodgepole pine can be labeled a "utility" species since it can be grown comparatively well in many management

situations, and used as a raw material for almost all forest products in the northern Rockies. Industrial land managers will increasingly realize and apply the many attributes of lodgepole pine forestry.

1301. COSTON, T. 1985. The future of lodgepole pine forestry--a public manager perspective in the USA. Page 353 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

1302. COUTANT, G.J. Forest esthetics - the key is management. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 588-595
4 ref.
Subject Codes: 8.5
CAB: 757871

A brief discussion of opportunities available to the landscape architect and the forester for the creation of aesthetically rewarding and economically profitable forest landscapes.

1303. DERMOTT, C.A. 1985. Future of lodgepole pine forestry: private manager' perspective in Canada. Pages 359-365 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

1304. FAHEY, T.D. Evaluating dead lodgepole pine for products.
Forest Products Journal, 1980, 30(12): 34-39
Subject Codes: N/A
RCA: X1208

1305. FAHEY, T.D. Value ranking for utilizing lodgepole pine residues. IN: Proceedings, Harvesting and Utilization Opportunities for Forest Residues in the Northern Rocky Mountains.
Gen. Tech. Rep. INT-110: 198[illegible]
Subject Codes: N/A
RCA: X1209

1306. HARRIS, J.M. Physical properties, resin content, and tracheid length of lodgepole pine grown in New Zealand.
New Zealand Journal of Forestry Science, 1973, 3(1): 91-109
11 ref.
Subject Codes: 7.4.3
CAB: 210351

Pinus contorta was planted extensively between 1926 and 1945 as an alternative to P. radiata on cold, wet sites. In the present study, increment cores were taken from 40 trees aged 32-40 years, from eight stands, six containing 'green' strains (P. contorta subsp. contorta) and two containing 'yellow' strains (P. contorta subsp. murrayana), and representing a wide range of site conditions. Detailed information is given on volume, radial growth rate, heartwood and late-wood %, moisture content, weighted mean density, shrinkage, resin content and tracheid length. Volume production and wood properties of the two 'green' strains were markedly superior to those of the 'yellow' strains; one of the 'green' strains, the 'Manning green strain' (from a Washington seed source) produced consistently denser wood than the 'Waiotapu green strain' (origin unknown). Densitometer studies showed that the general variation in wood density with site was due mainly to the production of low-density late wood on cold sites. The resin content of P. contorta is rather high (3%) which may restrict its use for groundwood pulp. In other respects its wood properties are those of a general-purpose softwood suitable for sawn timber or chemical pulping.

1307. HATTON, J.V., HUNT, K. 1985. Utilization of lodgepole pine in pulping. Pages 335-341 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Lodgepole pine is now widely accepted as a pulp furnish in contrast to its "weed species" designation of two decades ago. This was confirmed by a mill survey conducted in 1983 in the western United States and Canada aimed at quantifying the amounts of sound and beetle-killed lodgepole pine used, the pulping processes applied and the variety of end products for which these pulps are used. Seventy-two questionnaires were distributed to all mills in five states and two provinces. Of these, 61 mills responded; 26 were using some percentage of lodgepole pine in their pulping operations, including 23 which use some (amount generally unknown) percentage of mountain pine beetle-killed material. Nineteen of the responding mills use lodgepole pine to make kraft pulps, six make refiner mechanical or thermomechanical pulps and one make defibrated wood for a range of fibreboard products. Kraft and mechanical pulps from lodgepole pine are used for a wide variety of end products including fine papers, communications, packaging, tissue and newsprint grades.

1308. HEEBINK, B.G. Particleboard from lodgepole pine forest residue. USDA For. Serv. Research Paper, Forest Products Lab., Madison, 1974, No. FPL 221: 14 pp.
5 ref.
Subject Codes: N/A
CAB: 372088

After logging operations in Wyoming and Montana, Pinus contorta var. latifolia residues of diameter 3 inches were used to make various types of structural flakeboards, three- layer flakeboards (cores made from slivers or chips), particle boards and core-type particle boards. All boards were satisfactory. It is concluded that all sizes of residues can be used for three-layer boards with faces made from flakes and the core from slivers.

1309. HENLEY, J.W. Technical and economic aspects of harvesting dead lodgepole pine for energy. IN: Harvesting and Utilization Opprotunities for Forest Residues in the Northern Rocky Mountains: Proceedings of a symposium; 1979 November 28-30; Missoula, MT.
USDA For. Serv., Int. For. and Range Exp. Sta., 1981, Gen. Tech. Rept. INT-110: 213-216
Subject Codes: 8.5
RCA: X1126

This study highlights the results of a study of the economic feasibility of harvesting dead lodgepole pine for fuel and products. Costs, production rates, and recoverable wood volumes were obtained from a 3-month study of a whole-tree logging operation in which dead lodgepole pine was harvested for fuel and products.

1310. JOHNSTONE, W.D. Can we use the dog hair?
Can. For. Serv. Northern For. Res. Centre, 1972, For. Rep. 2(2): 8
Subject Codes: N/A
RCA: X1167

1311. KOCH, P. 1985. Utilizing lodgepole pine forests of the 21st century--a research program. Pages 343-349 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Process invention and application are the end products of research scheduled to fill the technological needs. Routes to achieving such invention vary with investigator. One route that has proven successful -- and is contemplated here -- calls for a step-wise procedure comprised of the following components, listed in sequence of accomplishment. Work to date is on schedule and on budget. 1982-1992. Search the lodgepole pine literature, and process literature applicable to lodgepole pine; digest this information. 1982-1984. From survey data, arrange to have the North American lodgepole pine resource tabulated and graphed by county (or survey unit). 1983-1984. Identify a few representative lodgepole pine acreages in the United States for which responsible land managers seek intensifies utilization. 1983-1984. Systematically sample the North American population of lodgepole pine (variety latifolia, and less intensively, murranyanna). 1985-1987. Characterize the representative acreages identified and publish an atlas depicting and describing these acreages in such a manner that new processes can be designed specifically for them. 1985-1990. From the systematic sample of trees,

characterize wood, bark, foliage, and roots of lodgepole pine as industrial raw materials. 1983-1991. Invent new processes and incorporate known processes into new manufacturing systems that should be profitable; make economic analyses of these systems; demonstrate the most promising. 1990-1992. Write a U.S. Department of Agriculture Handbook summarizing pertinent data on: the resource (with background data on physiology and silvics); characterization of representative acreages; characterization of wood, bark, foliage, and roots; and processes by which lodgepole pine is converted to products, and their economic feasibility. The needed processes should be moderate in capital, labor, water, and energy requirements, should accept trees of all diameter classes, and should yield high-value commodity products, with a high percentage of the complete tree (above- and below-ground biomass) ending as salable product.

1312. LITTON, R.B. Jr. Esthetic resources of the lodgepole pine forest. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 285-296
6 ref.
Subject Codes: 1.4
CAB: 757872

Pinus contorta forest is examined from two standpoints: its general relation to the landscape, and detailed variation within the forest type.

1313. LOWERY, D.P., HILLSTROM, W.A., ELERT, E.E. Chipping and pulping dead trees of four Rocky Mountain timber species.
USDA For. Serv., Intermountain For. and Range Exp. Stn., 1977: Res. Note INT-193
Subject Codes: N/A
RCA: X1171

1314. MAGNESEN, S. So far we do not know a great deal about Pinus contorta in Vestland.
Norsk Skogbruk, 1977, 23(9): 22-23
5 ref.
Language: no
Subject Codes: 7.4.1
CAB: 984172

The author briefly summarizes Norwegian experience to date and suggests caution. It is not thought likely that the species will prove suitable for mass cultivation in the region but its faster juvenile growth and greater hardiness compared with Pinus sylvestris may make it suitable for poor and exposed sites.

1315. MALONEY, T.M., TALBOTT, J.W. Utilization of forest and forest products reiduals.
Project WNP00410, Washington State Univ., Pullman, WA, 01 July 73 to 01 Jan 99
Subject Codes: N/A
CRIS: 0066001

Objectives: Convert forest slash, forest products manufacturing waste, non-commercial wood species, and non-wood fibrous material into building products by dry processes. Approach: The potential for converting the raw mateials will be studied by species, particle geometry, particle size, pH level, and specific gravity. Bonding resins will be studied by type and level with these raw materials for developing appropriate board strengths. Dimensional stability will be developed by the use of resins and other chemicals, heat treating, and oil tempering. Different treatments for imparting fire retardancy will also be part of the overall study. Molding techniques will be developed for manufacturing of building components of comminuted particles or fiber building panels composed of aligned flakes, particles, and fibers will be developed by means of electrostatic orientation. Such oriented products should meet or exceed the strengths of conventional wood products. Progress: Research has shown the dead timber resource in the interior West of western white pine and lodgepole pine is an excellent raw mateial for composition board manufacture. Problems occur when cutting wide flakes such as wafers; however, other standard types of boards can be produced. Manufacturing costs are similar to plants using green wood, and markets for medium density fiberboard and structural flakeboard appear to be available. Research on the use of isocyanate binder for particleboard showed the most important process variable was the effect of mat moisture content. In almost all cases, boards pressed at 18% moisture content were weaker than boards pressed

at either 4% or 10% moisture content. Differences in time between adequately cured and undercured board were as little as 18 seconds. It was then also observed that wax had a detrimental effect on board properties and this was related to the manner in which the wax was applied.

1316. MALONEY, T.M. 1985. Utilization of lodgepole pine forest and forest products residuals for composition board. Pages 325-330 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Lodgepole pine (Pinus contorta) mill residues have been used in composition board manufacture for many years, usually in mixture with other species. Research has shown that lodgepole pine is an excellent species for many types of composition board such as hardboard, medium density fiberboard, underlayment grade particleboard, industrial grade particleboard, oriented strand board, flakeboard, and waferboard. Large amounts of standing lodgepole pine killed by disease, insects, and fire are also available in the western United States and Canada. Some of this material can be used successfully to manufacture lumber and plywood, but most of it is unsuitable for such use. This lodgepole material, however, can be used effectively in manufacturing most types of composition board materials. An exception is waferboard where it is difficult to cut wide wafers from the relatively dry raw material (usually about 25% moisture content) without special pretreatments such as water soaking or steaming. It may also be possible to produce composition lumber or components from lodgepole pine.

1317. PELLERIN, R.F. 1985. Upgrading lodgepole pine lumber by nondestructive testing. Pages 331-334 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

Machine stress rating (MSR) is now well accepted for grading structural dimension lumber. Being that the MSR method establishes the grade based on the properties of the individual piece of lumber, the concept is species independent. MSR is best known for its application to species such as Douglas-fir and hemlock that have been well established for structural application. However, MSR grading of white woods is also successfully being done. The decision of whether to use MSR depends upon econcomics and the quality of wood that is being graded, regardless of species.

1318. ROGERS, M.T. The design of shelter belts for the Midlands (of England). IN: North American Elk: Ecology, Behavior and Management.
Timber Grower, 1979, No. 73: 12-15
Subject Codes: N/A
CAB: 1233568

Advice is given on the establishment, protection and choice of species for farm shelterbelts. The ideal texture is semi-permeable while providing shelter at different heights. Different species are recommended for speed of growth, low cost, edible fruit, timber production and wildlife; the components of the shelterbelt are classified into dominants, intermediates and hedge species. Recommended species for a single-row belt are thuya (Thuja plicata) or hawthorn (Crataegus monogyna) on clays and Leyland (Cupressocyparis leylandii) or beech on lighter soils.

1319. SHRIMPTON, D.M. Heart wood extractives of Pinus-contorta.
Am. J. Bot., 1971, 58(5 part 2): 480
Subject Codes: N/A
BIO: 72007012

1320. SMITHERS, L.A. Fence posts and poles from lodgepole pine stands.
Mimeograph. Dept. of Lands and Forests, Alberta, 1958
Subject Codes: N/A
RCA: X1036

1321. SUSOTT, R.A. Thermal behavior of conifer needle extractives.
For. Sci., 1080, 26(3): 347-360
Subject Codes: N/A
BIO: 71019772

Thermal generation of combustible vapors was measured up to 500 degree C. for green Douglas-fir, ponderosa pine and lodgepole pine foliage. The relative contributions to combustible products are given for ether, benzene-ethanol and total extractives, as well as for holocellulose and lignin. Each of these components makes a sizeable contribution of flammable vapors. Extractives account for about 80% of the volatiles below 300 degree C. Most of these low-temperature volatiles were extracted with benzene- ethanol, but only 15-30% were ether soluble. For these fuels, ether extractive content was of limited value as an indicator of differences in flammability.

1322. TAIT, R.M., HUNT, J.R., GASTON, C., BARTON, G.M. Utilization of lodgepole pine Pinus-contorta muka foliage by sheep.
Can. J. Anim. Sci., 1982, 62(2): 467-472
Subject Codes: N/A
BIO: 75046467

Eight sheep were used in two 4 .times. 4 latin square digestion trials substituting alfalfa meal with unsteamed or steamed muka (foliage) at levels of 20, 40, or 60%. Including muka at all levels depressed (P less than 0.05) the digestibility of dry matter, organic matter, crude protein and acid detergent fiber compared with the control alfalfa meal diet. When calculated by difference, the digestibility of muka dry matter and organic matter was not affected (P less than 0.05) by either the level of its inclusion in the diets or by steaming. The mean dry matter and organic matter digestibilities of muka were 29.2 and 30.4% respectively. The protein content of muka was 5.0% and the estimated protein digestibility at the 60% level of inclusion was only 6.6%. With unsteamed muka, the digestibility of acid detergent fiber calculated by difference averaged -11.9%, suggesting the presence of factors which depressed the digestibility of fiber in the basal diet. Steaming appeared to reduce this depression. A growth trial was conducted with lambs where alfalfa meal, as the sole roughage source, was compared to the same diet with 20% of the alfalfa replaced by steam muka. Growth rates were not different (P greater than 0.05) being 142 and 138 g/day, respectively. A taste panel evaluation of the carcasses found no adverse effects on flavor due to the inclusion of steamed muka in the diet.

1323. VANKAT, J.L., MAJOR, J. Vegetation changes in Sequoia National Park, California.
J. Biogeogr., 1978, 5(4): 377-402
Subject Codes: N/A
LISC: 267013

Twenty-one vegetation types occurring in Sequoia National Park are described and their changes under western man's influence are documented. Age-population structure of the trees, repeated old photographs, and historical descriptions were the primary evidence for recording and interpreting vegetation changes. These changes are strongly correlated with past land uses. Nineteenth-century livestock grazing is considered to be the primary factor in changes in the blue oak foothill woodland, lodgepole pine and subalpine forests, and various grassland vegetation types. Twentieth-century fire suppression is the primary factor in most changes in the various shrublands and other woodlands and forests. Vegetation changes include increases of introduced species in herb-dominated systems, and increases in cover and density of certain woody plants in tree and shrub-dominated vegetation types.

8.2 PURPOSE

1324. GALLAGHER, G.J. Scarification and cultural resources - an experiment to evaluate serotinous lodgepole pine forest regeneration techniques.
Plains Anthropol., 1978, 23(82 part 1): 289-299
Subject Codes: 7.1, 7.6.1, 8.8
BIO: 67041122

The controlled analysis of the effects of natural resource management techniques

on cultural resources was rarely undertaken. Scarification is used by timber managers to mix soil and seed to insure proper regeneration in harvested areas. The effects of l scarification project on an artifical site are described and the resultant disturbance evaluated in light of its potential to affect cultural resources. Suggestions for meeting timber management goals while minimizing impacts on cultural resources are offered.

## 8.3 PRINCIPLES

No references found.

## 8.4 OPERATIONS

1325. ALDRED, A.H., LOWE, J.J. Application of large-scale photos to a forest inventory in Alberta, Canada.
Can. For. Serv. For. Manage. Inst. Information Report FMR-X-107, 1978: 57 pp.
Language: en
Summary Languages: fr
Subject Codes: N/A
BIO: 15043937

For a number of years the Forest Management Institute has been developing a forest inventory method based on large-scale aerial photographs on which individual trees can be identified and measured. The aim is to eliminate most of the fieldwork required to collect tree species, height, diameter, basal area, stocking, and volume data on sample plots. Recently the method has been tested under different operational conditions with a view to simplifying the method and overcoming a few remaining problems. The purpose of the present project was to apply the improvements to a full-scale photo inventory in the context of an operational survey. A 3 000 km2 forest management unit located in the Peace River district of Alberta requiring a volumetric inventory was used as the test area. The trial was conducted as a cooperative undertaking between the Alberta Forest Service and the Forest Management Institute - both agencies committing financial and manpower resources. Considerable attention was paid to the analysis of factors influencing the accuracy of the inventory results and the cost of doing the work.

1326. BENSON, R.E. Management consequences of alternative harvesting and residue treatment practices-lodgepole pine.
Intermountain Forest and Range Experiment Station, Ogden, UT. 64 pp.
Subject Codes: 7.1, 8.5
RCA: X1133

Logging residues in lodgepole pine were treated by four methods: broadcast burned, piled and burned, removed from site, and chipped and spread on site. Each treatment was regenerated by planted seedlings. Microorganisms, vegetative development, wildlife habitat, and visual qualities were observed during a 10-year period. Analyses were made of immediate and projected long-term costs and benefits for both dollar and non- dollar resource values.

1327. BERGLUND, J.V., YOUNG, G.M. Energy requirements for replacing nutrients lost by whole tree logging.
Project NYZ-2414-20-001, Col. of Environ. Sci. & Forestry, Syracuse, N.Y., 15 Apr 78 to 01 Sep 80
Subject Codes: 3.3. 5.6
CRIS: 0085571

Objectives: Evaluate the impact of plant nutrient removal through whole tree utilization. Assess the extent and degree of soil disturbance and compaction. Evaluate changes in soil moisture and temperature regimes as they might affect lodgepole pine regeneration. Approach: Five clearcuts will be intensively

utilized to obtain pertinent field data regarding nutrient removals and various physical environmental variables. The biomass and chemical composition of residual materials will be estimated or measured. Progress: The study evaluated the total nitrogen exported as a result of whole tree logging of the Pinus contorta Douglas component and residue material in seven northeastern Oregon stands. Calculations of the energy required to replace losses through the use of inorganic fertilizers were made. Results from the current study indicate that: Because the energy output is dependent upon the biomass removed, which is, in turn, dependent upon the utilization standards used, separate estimates must be obtained for each individual area being studied. The amount of nutrients removed during a harvest operation are also dependent upon the utilization standards, as well as certain physiographic factors, including time of harvest, species, age, and various site-specific factors. Therefore, these estimates must also be obtained independently for each area being studied. A positive net energy gain occurs when the energy needed to replace the lost nitrogen using inorganic fertilizers is the energy input considered. However, the addition of various other inputs would probably not reduce the net energy gain significantly, although this must be determined for each particular study, along with the other estimates previously mentioned. Possibly the most important conclusion reached by this preliminary investigation is that it is possible, through careful planning and management, to obtain a worthwhile net energy gain.

1328. BERNSTEN, C.M. management conflicts in lodgepole pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 503-515
Subject Codes: 3.2, 7.5
CAB: 757562

Clear felling has been the most widely used harvesting method in Pinus contorta stands in the Rocky Mountains. This paper discusses harvesting methods in relation to scenic quality, wildlife, recreation, reforestation and logging residues, and makes suggestions as to the size, location and timing of clear fellings.

1329. BROWN, J.K. Reducing fire potential in lodgepole pine by increasing timber utilization.
USDA For. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1974, No. INT-181: 6 pp.
4 ref.
Subject Codes: 6.3, 7.1
CAB: 419154

Presents further results from a study in two stands of Pinus contorta var. latifolia 167- 182 years old in Wyoming in which 'conventional' harvesting (a) and 'near-complete' harvesting (b) were compared on sample plots. Measurements of the amount and depth of fuel material remaining on the ground showed that for material of diameter greater than 3 inches (a) resulted in three times and (b) in one-third the amount of fuel before felling. Potential fire spread was 3-4.5 times as great, and potential intensity of the flame front almost 9 times as great, after (a) as after (b). After (b), fire hazard was minimal, but prescribed burning (e.g. as a silvicultural treatment) was impracticable since not enough fuel remained.

1330. GARDNER, R.B., HANN, D.W. Utilization of lodgepole pine logging residues in Wyoming increases fiber yield.
USDA FOR. Serv. Research Note, Intermountain For. and Range Exp. Stn., 1972, No. INT-160: 6 pp.
1 ref.
Subject Codes: 8.1
CAB: 083755

In a study in two stands of Pinus contorta in W. Wyoming, "conventional" harvesting (a) and "near-complete" harvesting (b) were compared on sample plots within each stand; specifications for (b) differed from those for (a) in requiring on-site conversion to chips of the tops of all merchantable trees, all residual standing trees and sound dead trees of d.b.h. more than or equal to 3", and all suitable logs on the ground. The fibre yield from (b) was 35% greater than from (a), although the difference was not significant under the conditions of this study.

1331. GARDNER, R.B., HARTSOG, W.S. Logging equipment, methods, and cost for near complete harvesting of lodgepole pine in Wyoming.
USDA For. Serv. Research Paper, Intermountain For. and Range Exp. Stn., 1973, No. INT-147: 15 pp.
1 ref.
Subject Codes: N/A
CAB: 305000

A further report on a study comparing 'conventional' and 'near-complete' harvesting of Pinus contorta. Methods and equipment employed in the logging operations are described and costs are analyzed. A carefully scheduled operation using the most productive equipment is proposed for 'near-complete' harvesting which would give significant cost savings.

1332. HAMEL, D.R., AMMAN, G.D., et al. Harvesting strategies for management of mountain pine beetle infestations in lodgepole pine Montana, USA - establishment report.
U.S. For. Serv. North Reg. Insect Dis. Rep., 1975, 75(12): 11 pp.
Subject Codes: 6.1
BIO: 76023069

1333. HART, G.E., DE BYLE, N.V. Effects of lodgepole pine logging and residue disposal on subsurface water chemistry. IN: Proc. of Watershed Management Symp., ASCE Irrigation & Drainage Div., Logan, Utah, Aug. 11-13, 1975. 1975: 98-109
13 ref.
Subject Codes: 3.2, 3.3
CAB: 630705

Reports preliminary conclusions on the effect of logging in a mature Pinus contorta stand in western Wyoming, followed by four different methods of slash disposal (broadcast and burnt, windrowed and burnt, chipped and spread, chipped and removed), on sub-surface water chemistry. There was an apparent slight increase in the concentration of several nutrients in soil solutions at depths of 0.6-1.2 m after logging and disposal of debris but, except for a flush of nutrients after broadcasting and burning, there were no apparent differences in soil solutions after the four treatments. Concentrations of phenol in soil solutions, especially under the areas treated by chipping, were much greater than under undisturbed forest.

1334. HOST, J., SCHLIETER, J. Low cost harvesting systems for intensive utilization in small stem lodgepole pine stands.
USDA For. Serv. Intermountain For. and Range Exp. Stn., 1978: INT-201
Subject Codes: N/A
RCA: X1165

1335. JAMIESON, K.M. Management of contorta pine regeneration in Karioi forest for production.
New Zealand Journal of Forestry, 1974, 19(1): 93-101
7 ref.
Summary Codes: 7.4.1, 7.7, 7.9
CAB: 380456

In 1928-33, ca. 2000 ha of Karioi Forest, central North Island, New Zealand, were planted with Pinus contorta, and since then the species has regenerated naturally over large areas of tussock lands adjoining the forest. This paper describes the management of the regenerated stands (mainly of the 'green', coastal provenance) for pulpwood or sawlogs. Pruning and thinning were started in 1959, and by 1972 some 300 ha had been treated. There were no establishment costs and tending costs were relatively low: low pruning costs averaged $37.50/ha (450 stems/ha pruned to a height of 3 m), and thinning to 1250 stems/ha averaged $40.00/ha. Response in terms of increased diameter growth is good. Some consideration is given to the risk of maintaining these stands as a possible seed source, in view of the potential of the species as a weed tree.

1336. KEAYS, J.L., SZABO, T. Forest yield is increased by pulping tops.
Pulp & Paper, 1974, March: 4 pp.
19 ref.
Subject Codes: 5.2, 8.1
CAB: 355197

Results of research in Canada (Alberta) on the use of tops of Pinus contorta, Picea glauca and P. mariana in sulphate pulping show that this practice can increase the yield of the forest by 5-10% without any significant adverse effect on pulp yield or strength.

1337. MYERS, C.A. Computerized preparation of timber management plans: TEVAP2.
USDA For. Serv. Resarch Paper, Rocky Mountain For. and Range Exp. Stn., 1974, No. RM-115: 72 pp.
13 ref.
Subject Codes: N/A
CAB: 363626

After 2 years of testing with the TEVAP (Timber Evaluation and Planning) programme in the Black Hills National Forest, the procedures and programme were revised. The new programme given is applicable to Pinus ponderosa and Pinus contorta var. latifolia and changes and additions for use with other species are explained.

1338. OSWALD, E.T. Terrain analysis from Landsat imagery.
Forestry Chronicle, 1976, 52(6): 274-282
24 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 747031

The use of LANDSAT imagery was evaluated in an area of 50 X 400 km with diverse topography and vegetation in interior British Columbia, by relating features to those shown in high and low level photography and maps. Major landscape features and vegetation types were easily distinguished on the images, which are produced from 4 scanners covering different wavelengths of reflected light. Tonal differences (or colour differences in Diazo contact prints of the images) in forested areas indicate variations in density, age and species: for example mature and older stands of spruce (Picea spp.) and hemlock (Tsuga heterophylla) have darker tones than lodgepole pine (Pinus contorta). Logged areas are revealed as light-toned, with straight edges. The use of sequential imagery for studying changes in the landscape is discussed; for example the progress of harvesting operations, or the processes of erosion and silting, which are shown by tonal changes.

1339. PACKER, P.E., WILLIAMS, B.D. Logging residue disposal effects on surface hydrology and soil stability of lodgepole pine forests.
Gen. Tech. Rep., Intermountain For. and Range Exp. Stn., 1980, INT-90: 111-122
Subject Codes: 8.8.3
LISC: 575335

In the high-elevation Pinus contorta forests of western Wyoming, the most effective logging residue disposal treatment in terms of surface runoff and erosion control is chipping the residue and respreading it as a protective mulch. this treatment has serious disadvantages - almost complete suppression of vegetation and elimination of natural lodgepole pine reproduction. The most adverse soil and vegetative characteristics, the poorest surface runoff and erosion control, and the slowest watershed recovery occur where logging residue has been dozer piled and burned. Chipping and removing the chips is a superior treatment for watershed protection, but may not be economically practical. Broadcast burning remains the most effective residue treatment in terms of protection of soil and vegetal characteristics, control of surface runoff and soil erosion, and rapidity of watershed recovering following logging.

1340. POWELL, L.H. Evaluation of new logging machines: Warner & Swasey FB-522 Feller-Buncher.

Logging Research Reports, Pulp and Paper Research Institute of Canada, 1973, No. LRR/50: 22 pp.
7 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 122176

The prototype of this feller/buncher (makers: Warner & Swasey Co., Solon, Ohio, USA) was studied in British Columbia in June, 1972 during a whole-tree logging operation in Pinus contorta var. latifolia forest. Average harvesting time per tree was 0.71 min. The most important factors affecting harvesting time per tree were volume per tree, differences between operators and the proportion of saplings to merchantable trees. Average volumes per tree and per bunch were 9.4 ft3 and 79 ft3 respectively. A trial of the effects of increasing bunch size showed that a bunch volume of 156 ft3 was attainable without any significant increase in harvesting time per tree. Average output (calculated from average harvesting time per tree) was 7.9 c units per productive machine-hour. (The machine studied is the only one in operation in Canada, the manufacturer having decided to discontinue the development and construction of logging machines.)

1341. RASKE, A.G. Relationship between felling date and larval density of Monochamus scutellatus.
Bi-monthly Research Notes, 1973, 29(4): 23-24
8 ref.
Language:
Summary Languages:
Subject Codes: 6.1
CAB: 226917

Picea glauca, Pinus contorta, and Pinus banksiana were felled at two sites in Alberta in April, June, August, October and December, to determine the effect of felling date on intensity of infestation by larvae of M. scutellatus. Infestation was significantly higher in summer-felled logs, and it is recommended that, wherever possible, felling should be done in autumn or winter, and logs processed and removed promptly. Where logs must remain in the forest, those felled in autumn or winter should be left, as they are likely to contain fewer larvae in the following autumn than spring-felled logs.

1342. SMITH, F.W. Mountain pine beetle activity in relation to site and stand variables in lodgepole pine in Colorado.
Project COLZ00523, Colorado State Univ., Fort Collins. COL., 01 Oct 82 to 30 Sep 83
Subject Codes: 6.1
CRIS: 0088638

Objectives: The objective of this study is to develop a risk rating system for stands of lodgepole pine in western Colorado which are threatened by mountain pine beetle infestation. This rating system can be used to identify stands which are susceptible to infestation and would require silvicultural control measures to develop resistance. Also, the short and long term results of silvicultural treatments can be evaluated using this risk rating system. Approach: Stand characteristics and site factors will be examined with respect to beetle activity and related tree mortality to identify conditions which indicate density will be taken in a number of locations across a range of stand characteristics including site, age and stocking levels. These measures will be used to characterize stand and tree vigor. Vigor will then be correlated with beetle activity mortality to develop an index of tree resistance to infestation.

1343. STAGE, A.R. Forest stand prognosis in the presence of pests: developing the expectations. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Serv., 1973, publ. 1975: 233-245
7 ref.
Subject Codes: 6.1, 7.7
CAB: 770108

A method for predicting stand development under alternative management regimes is extended to include the likelihood of a pest outbreak. An example is given of the effect of infestations of Dendroctonus ponderosae on stand prognoses for Pinus contorta. The procedures for calculating expectations are illustrated by

comparing 3 thinning options and two pest management options.

1344. STUTH, J.W., WINWARD, A.H. Logging impacts on bitterbrush lodgepole pine pumice region of central Oregon.
J. Range Manage. 1976, 29:453-456
Subject Codes: N/A
RCA: X1099

Shrub and herbaceous production for unlogged and logged conditions is tabulated. Overstory is predominantly Pinus contorta.

1345. TUCKER, G.F. Environmental harvesting of lodgepole pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 596-601
Subject Codes: 7.5
CAB: 757564

Harvesting practices for Pinus contorta have developed from selective felling before the mid-1940's to clear felling of large regular areas in the early 1960's. Adverse public reaction has caused a change to clear felling of smaller irregular areas designed to blend in with the forest surroundings. A study in Wyoming on the effect of harvesting on the environment considers utilization of logging residues, effects on regeneration, aesthetic values, wildlife habitat, etc. Initial results indicate that utilization of logging and forest residues results in a large increase in the weight of fibre removed as compared to conventional harvesting methods, and an increase in the aesthetic acceptability of the cleared areas.

1346. WALSH, S.J. Coniferous tree species mapping using Landsat data.
Remote Sens. Environ., 180, 9(1): 11-26
Subject Codes: N/A
BIO: 70008571

The identification and mapping of 12 surface-cover types within Crater Lake National Park, Oregon, USA, including 8 coniferous tree species - Abies magnifica shastensis, Tsuga mertensiana, Pinus contorta var. latifolia, A. concolor, P. ponderosa, Pseudotsuga menziesii, Pinus lambertiana and P. monticola: was accomplished through the use of LANDSAT digital data. The 12 surface-cover types were mapped with an average accuracy of 88.8%, as compared with detailed ground truth. The classification of LANDSAT data was accomplished through use of the Interactive Digital Image Manipulation System (IDIMS) available at the EROS Data Center in Sioux Falls, South Dakota. The combined effects of a quantity and quality of ground truth, the use of the controlled clustering classification technique, and the prudent placement of Intensive Study Areas (ISA) on the image-processing CRT screen for training statistic collection provided very subtle spectral reflectance differences between coniferous tree species. Slope angle, slope aspect and surface-cover type variation, and to a lesser degree, crown siz and crown density were the main environmental factors that accounted for spectral reflectance variation of surface-cover types within the park. Through an appreciation for the influence of environmental factors on the reflectance value of surface-cover types and an appreciation for the placement of training areas to sample the environmental effects on reflectance, one can reduce misclassification or nonclassification possibilities.

## 8.5 ECONOMICS

1347. BENSON, R.E. Lodgepole pine logging residues: management alternatives.
USDA For. Serv. Res. Pap. INT-160, 1974: 28 pp.
Subject Codes: 8.1, 8.4
RCA: X1119

Dollar and non-dollar values are compared for alternative residue utilization levels in mature lodgepole pine. However, substantial non-dollar benefits were

gained by near- complete harvesting, especially in esthetics, fuel reduction, and site preparation. Continuing studies of harvesting influences upon soils, hydrology, nutrients and regeneration will further define costs and benefits, and will provide managers with guidelines for harvesting practice decisions.

1348. DOBIE, J., WRIGHT, D.M. Lumber values from beetle-killed lodgepole pine.
Forest Products Journal, 1978, 28(6): 44-47
6 ref.
Subject Codes: 6.1
CAB: 948046

Pinus contorta var. latifolia trees in a part of the E. Kootenay region, B.C., heavily attacked by Dendroctonus ponderosae, were sampled in 4 classes based on foliage and bark characteristics related to time since beetle attack. Lumber recovery factors and grade yields are tabulated. Net values for "green top" and "red top" classes were similar ($8-10/100 ft3 of logs); those for the "grey, tight bark" class were $5-6 less. Returns for the "grey, loose bark" class were negative.

1349. HEINSTEDT, D. The economics of growing Pinus contorta.
Sveriges Skogsvardsforbunds Tidskrift, 1972, 70(4): 315-335
16 ref.
Language: sv
Summary Languages: en
Subject Codes: 5.0
CAB: 068033

Discusses stand development, diameter structure, volume increment, quality, and net financial yield in comparison with P. sylvestris on the basis of published and unpublished Swedish trials and a model calculation. It is concluded that though the yield of some provenances of P. contorta exceeds that of Swedish Scots Pine, the material available is insufficient for economic comparison with acceptable confidence.

1350. JOHNSON, D.W., HAWKSWORTH, F.G., DRUMMOND, D.B. Yield loss of lodgepole pine Pinus-contorta stands to dwarf mistletoe arceuthobium-americanum in Colorado and Wyoming, USA National Forests.
Plant Dis., 1981, 65(5): 437-438
Subject Codes: 5.0, 6.2
BIO: 72069354

From 1977 - 1979, a road and plot survey was conducted for A. americanum in lodgepole pine (P. contorta) stands on 9 national forests in Colorado and Wyoming. Infestation levels ranged from 0-64% and averaged 50.6% for all forests surveyed. Estimates of annual merchantable loss to dwarf mistletoe by forest ranged 880-101,930 m3 (0.40-1.36 m3/ha). The annual loss for these forests is estimated at 270,750 m3 (average, 0.76 m3/ha). This loss is equivalent to the annual harvest of lodgepole pine sawtimber for these national forests or at least 25% of the annual growth.

1351. O'BRIEN, D. Economics of spacing, respacing and thinning. IN: Growing Spacing i Conifer Crops.
Irish Forestry, 1980, (37): 77-96
19 ref.
Subject Codes: 7.5, 7.6, 7.7
CAB: 1369089

An economic evaluation is presented of a number of silvicultural treatments including spacing, respacing and thinning in Sitka spruce and coastal lodgepole pine stands in the Irish Republic. The results show, for the two prices assumed, that lower crop densities than those now practised lead to greater profitability if wood quality is not drastically reduced. From author's summary.

1352. O'FLANAGAN, L. Lodgepole pine - silvicultural alternatives. IN: Growing Space in Conifer Crops.
Irish Forestry, 1980, (37): 68-76
6 ref., 1 pl.

Subject Codes: 7.5, 7.6, 7.7, 7.9
CAB: 1369088

Costs were estimated of 3 silvicultural options for a 9-year old stand established at 2X1.5 m spacing on deep peat (raised bog) in Loch Ennel forest, Irish Republic: (a) normal practice as envisaged in standard yield tables with high pruning (to 6 m) of 400 stems/ha; (b) immediate respacement to 800 stems/ha with high pruning up to 17 years old, and clear felling at 35 years old; and (c) a no-thinning regime with rotations of 30, 40 or 50 years. Option (b) gave the best net discounted revenue at all interest rates (2-10%). Respacement was done at this site with urea treatment of all stumps (against Fomes annosus (Heterobasidion annosum); all debris was left on site.

1353. SCHWEITZER, D.L. Economics of producing lodgepole pine stumpage. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 614-626
6 ref.
Subject Codes: N/A
CAB: 757725

Very little research has been done on the economics of producing Pinus contorta and this is attributed to low stumpage values and and higher-than-average logging costs. It is concluded that further development and utilization will have to depend on non- economic rationales.

## 8.6 PROBLEMS

1354. DAVIES, E.J.M., LINES, R. Useless? The case against contorta.
Scottish Forestry, 1980, 34(2): 110-113
1 ref., 2 pl.
Subject Codes: N/A
CAB: 1286066

Some disadvantages of Pinus contorta in Scotland mentioned (especially compared to Sitka spruce) are its low production, poor resistance to exposure (often leading to crooked stems), and susceptibility to windthrow (coupled with rapid degrade of timber), snow, deer damage and insect pests (especially Panolis flammea). (A reply by Lines, R., on p. 114-116 defends the use of lodgepole pine in Scotland and notes that the P. flammea outbreak began in stands of a little-used South Coastal provenance.)

1355. MARTINSSON, O. Lodgepole pine in the Swedish reforestation - problems and prospects. IN: Proc. from the 7th Int. Workshop on Regeneration of North Latitude Forest Lands, Hinton, Alta., August 1982 (in press).
Subject Codes: 7.4.3
RCA: X1022

1356. TACKLE, D. Lodgepole pine management in the Intermountain Region - a problem analysis.
U.S. For. Serv. Intermount. For. and Rge. Expt. Paper, 1953
Subject Codes: N/A
RCA: X1219

## 8.7 NEEDS

1357. MARTIN, R.E., BARRETT, J.W., COCHRAN, P.H. Culture of forests of easterm Oregon and Washington.
Project PNW-1203, Pacific NW For. and Range Exp. Sta., Bend, ORE, 01 Jan 68 to 08 Sep 83
Subject Codes: 6.1, 7.0, 8.0
CRIS: 0016067

As old-growth ponderosa and lodgepole pine forests are harvested there is an urgent need for information on managing the young existing stands and those to be planted. Numerous spacing and levels-of-growing-stock studies established in the early 1950's are now being written for publication and are about 80% complete. Fertilization studies in young stands of ponderosa and lodgepole pine are 75% complete. A stand growth simulator for newly established stands of lodgepole pine is 99% complete, and a similar simulator for ponderosa pine is 75% complete. The mountain pine beetle insect problem in both species is being addressed and some encouraging progress has been made toward a system of stand regulation to control insect populations. Prediction equations were developed to roughly estimate regeneration success on various sites after clearcutting and shelterwood cutting. Stocking level curves developed for managed Douglas-fir and grand fir stands, with site index curves and gross yield information previously developed will permit estimation of stand performance in simulation models. Workshops, consultations, and publications are being used to help management develop prescriptions to solve their prescribed burning problem.

## 8.8 LAND USE

1358. BAKER, G. Examples of different methods of slope stabilization.
N.Z. For. Serv., For. Res. Inst., FRI Symp., (16), 1978: 175-180
Subject Codes: 7.4.4
BIO: 17015181

1359. LEDGARD, N.J., BAKER, G.C. Growing trees for erosion control in New Zealand's high country.
What's New in Forest Research, 1979, No. 77: 4 pp.
4 pl. (3 col.)
Subject Codes: N/A
CAB: 1395475

A brief illustrated account of research on the establishment of tree cover on deforested slopes at 700-1300 m altitude, covering the preparation of planting stock, species and provenance selection and aerial seeding (direct sowing). Good germination and establishment were achieved with aerial seeding, but few seedlings survived the winter. Suitable grass/legume cover mixtures are being developed to prevent frost lift; their establishment requires an opt. amount of fertilizer in order to avoid excessive competition with the tree seedlings. Comparisons with natural vegetation showed that the annual increment of aerial biomass of lodgepole pine (9-12 t/ha at 1300 m alt.) was about double that of the native Nothofagus bolandri var. cliffortioides (3-5 t/ha at 1100 m alt.). (Based on the work of Ledgard, M.J., Barker, G.C.)

1360. PIMM, R.M. Glenfeshie: an achievement in conservation.
Scottish Forestry, 1979, 33(3): 180-185
1 ref.
Subject Codes: 7.4.2
CAB: 1203617

An account of a plan by the present owners (since 1966) of this 16 200 ha estate in the Scottish highland, mainly above 600 m alt., in collaboration with the Nature Conservancy and Forestry Commission. The only woodlands remaining at the start of the plan were remnants of the former Caledonian pine forest and birch scrub along the river. Management objectives were defined as: (1) improvement of quality and productivity of red deer (Cervus elaphus) and (2) restoration of tree cover for production, amenity, game habitat and conservation purposes. Planting was planned in 3 phases of 20 yr (the estimated time from deer exclusion to readmission) to minimize the loss of deer habitat: in phase 1, 486 ha was planted in 1970-76, mainly with Scots pine of local provenance and with lodgepole pine as

a nurse in most blocks. Marginal strips and small groups of birch and other native broadleaves were included. Problems of protection from deer browsing, optimum forest area and deer carrying capacity are discussed.

1361. PROCKTER, N.J. Conifers that tolerate coastal conditions.
Parks Sports Grounds, 1978, 43(4): 36, 38
Subject Codes: 7.4.4, 8.8.2
LISC: 069507

Cupressocyparis leylandii is ideal for planting in coastal conditions as it is frost hardy, salt and wind resistant. It is useful for hedge screens or shelter belts and succeeds in all types of soil and climate. Other conifer species that survive well and are attractive near the coast are described. They include Pinus contorta, the dwarf mountain pine, Pinus mugo, P. pinea, P. nigra, P. radiata and various juniper species.

8.8.1 WILDLIFE

1362. ARCHIE, M.A., HUDSON, R.A. Scattered mixed coniferous forest in subalpine meadows and spruce bogs.
Am. Birds, 1973, 27(6): 1002-1003
Subject Codes: N/A
BIO: 74050563

1363. ARMSTRONG, D.M. Ecological distribution of small mammals in the Upper Williams Fork Basin, Grand County, Colorado.
Southwestern Naturalist, 1977, 22(3): 289-304
27 ref.
Subject Codes: N/A
CAB: 856549

The distribution of 9 small mammal species was studied in relation to vegetation type along transects at alt. 2590-3475 m. Eight vegetational types were recognized in an initial survey, but the distribution of small mammals suggested that these could be grouped into only 3 broad habitat types of importance to the mammals. These were: (a) sagebrush parklands (Artemisia/Potentilla); (b) sub-aquatic to mesic meadows, thickets (Salix planifolia) and woodland (Populus tremuloides); and (c) coniferous forests (Picea engelmannii, Abies lasiocarpa, Pseudotsuga mensiesii and Pinus contorta). Habitat physiognomy seemed to be more important to the animals than the species composition of the overstory.

1364. AUSTIN, D.D., PERRY, M.L. Birds in six communities within a lodgepole pine forest.
Journal of Forestry, 1979, 77(9): 564-586
15 ref.
Subject Codes: 3.2
CAB: 1329681

A census of birds was taken in 6 communities in a lodgepole pine forest in the Uinta Mountains of Utah; mature and stagnated stands; openings made by clear felling in 1940 and 1960 with regenerating lodgepole pine; and wet and dry meadows. Some 36 species of bird were present but during the census counts only 25 were observed. Highest densities and numbers of species were found in the dry meadows. A few species were adversely affected by clear felling, but many were more numerous in such areas than in unlogged stands and the number of species remained constant. Stagnated stands contained very few buds.

1365. AUSTIN, D.D., URNESS, P.J. Small mammal frequencies in four communities within the lodgepole pine ecosystem.
Encyclia, 1977, 54(1): 39-41
Subject Codes: N/A

LISC: 257112

The relative abundance of small mammals in 4 communities within the lodgepole pine (Pinus contorta) forest is reported. Of the 127 mammals collected, 60% were deer mice (Peromyscus maniculatus), 18% were Say's chipmunks (Eutamias quadrivittatus umbrinus), 12% were flying squirrels (Glaucomys sabrinus), 5% were least chipmunks (E. minimus), 4% were mountain cotton tails (Sylvilagus nutallii) and 1% were red squirrels (Tamiasciurus). The distribution of these species in dry meadow, mature, stagnated, and clearcut forest was determined. It is concluded that man-made openings in the forest contained more small mammals than the mature or stagnated forest types, but natural openings contained fewest. The larger mammals reacted unfavourably to man-made and natural openings, and consequently the mature and stagnated forest types supported more weight.

1366. BOYCE, M.S., HAYDEN-WING, L.D. (Editors) Summer-fall food habits and forage preferences of a western Montana elk herd. IN: North American Elk: Ecology, Behavior and Management.
Laramie, Wyoming, U.S.A., University of Wyoming, 1979: 54-62
22 ref.
Subject Codes: N/A
CAB: 1233534

Another account of a study of forage use by the Rocky Mountain elk (Cervus elaphus (Canadensis) nelsoni) in 1971 and 1972 in an area of ponderosa pine, Douglas-fir, or subalpine fir (Abies lasiocarpa) as climax species, with western larch (Larix occidentalis), Engelmann spruce, lodgepole pine, and whitebark pine (Pinus albicaulis) and seral (and often dominant) species. Approx. one third of forage was browse and included Populus tremuloides and P. trichocarpa (from feeding site observations), and whitebark and lodgepole pines and Douglas-fir (from rumen analysis).

1367. COLLINS, W.B., URNESS, P.J. Habitat preferences of mule deer (odocoileus-hemionus) as rated by pellet group distributions.
J. Wildl. Management, 1981, 45(4): 969-972
Subject Codes: N/A
BIO: 22030884

1368. COLLINS, W.B., URNESS, P.J., AUSTIN, D.D. Elk diets and activities on different lodgepole pine habitat segments.
J. Wildl. Manage., 1978, 42(4): 799-810
Subject Codes: N/A
BIO: 68002053

The biweekly diets of tame elk (Cervus canadensis) were established on a species dry-weight basis for different habitat segments in the lodgepole pine (Pinus contorta) type. Principal species in the diets (those comprising 5% or more) on each habitat segment were generally composed of preferred species. Some highly abundant but nonpreferred species took on principal dietary status, whereas some preferred species, scarce in the vegetation, contributed less than 5% to diets. Forbs contributed most to total diet; grasses and sedges were the second largest contributors. Browse appeared to be of limited importance, but mushrooms had significance in forested habitat segments. Preference changes were evident as forb species matured. Consumption rates were significantly higher in habitat segments having greater species diversity and forage density. The time tame elk spent grazing, ruminating, lying, grooming, traveling, standing, drinking and playing were referenced to specific habitat segments in which each activity occurred. Individual elk activity (1008 h) was observed over six 24 h periods. Wet meadows, dry meadows, clearcuts and revegetated roads were preferred as grazing sites, while mature and stagnated forests were clearly nonpreferred. Wet meadows, revegetated roads and mature forest were preferred for resting and nongrazing activities.

1369. DEALY, J.E. Management of Lodgepole Pine ecosystems for range and wildlife. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University, Cooperative Extension Service, 1973, publ. 1975: 556-568
22 ref.
Subject Codes: 7.5, 7.7, 8.1
CAB: 769962

Management of Pinus contorta ecosystems for the provision of shelter and forage for domestic livestock and wildlife is reviewed. Lack of shelter discourages foraging by wild ungulates in large clear-felled areas although domestic stock will forage over openings of any size. Clear-strip felling or residual patches of cover are suggested for enhancing use of large clear-felled areas by wild ungulates. Forage production is greatly increased by thinning and clear fellings. Where livestock and wildlife compete for forage, manipulation of grazing by livestock may be necessary to ensure winter forage for deer.

1370. DESCHAMP, J.A., URNESS, P.J., AUSTIN, D.D. Summer diets of mule deer from lodgepole pine habitats.
J. Wildl. Manage., 1979, 43(1): 154-161
Subject Codes: N/A
BIO: 68021258

Five major subunits, or habitat segments, were recognized in the lodgepole pine (Pinus contorta) ecosystem in northeastern Utah (USA). Tame mule deer (Odocoileus hemionus hemionus) obtained significantly greater dry-weight consumption per unit time spent feeding on natural and created openings compared to forested segments. Ranking in descending order as forage sources for deer were: clearcut forest, dry and wet meadows, mature forest and stagnated forest. Forbs were the most important forage class in diets from all habitats, but especially nonforested ones when forbs average 91% compared to 61% on forested segments. The difference in forb production on the same comparison was great, 533 and 22 kg/ha, respectively.

1371. FRISSELL, S.S. Disturbed Douglas-fir, lodgepole pine forest.
Am. Birds, 1973, 27(6): 1001
Subject Codes: N/A
BIO: 74050561

1372. GASHWILER, J.S. Bird populations in 4 vegetational types in central Oregon,USA.
US Fish, Wildl. Serv. Spec. Sci. Rep - Wildl., 1977, (205): 20 pp.
Subject Codes: N/A
BIO: 64055778

A long-term study of birds to obtain baseline population data in relatively undisturbed major plant types was started in Deschutes County, Oregon (USA), in 1971. Four study areas were established. The big sagebrush (Artemesia tridentata) and western juniper (Juniperus occidentalis) areas are located about 34 and 31 km southeast of Bend, Oregon, on open range and on the Horse Ridge Research Natural Area, which are administered by the Bureau of Land Management. The ponderosa (Pinus ponderosa) and lodgepole pine (P. contorta) areas are in the Pringle Falls Research Natural Area about 56 km southwest of Bend on land administered by the US Forest Service. Plant surveys were done for each area. The estimated numbers of breeding bird territories per 40.5 ha by the spot mapping method for 1971-73 were obtained. These data show yearly variations in the bird population estimates and diversity but rankings in a given year by type are reasonably uniform. Changes within types are normal and should be considered carefully when evaluating environmental influences. Winter bird numbers obtained by the Emlem transect count method were more variable. Many of the wintering birds are arboreal and their abundance seemed related to known variations in the tree seed crop and to weather conditions.

1373. HEIN, D. Management of lodgepole pine for birds.
Gen. Tech. Rep., Intermountain For. and Range Exp. Stn., 1980, INT-86: 238-246
Subject Codes: N/A
LISC: 566587

Communities of birds in lodgepole pine (Pinus contorta) are among the least studied of all major forest types. General guidelines for current management are discussed, and recommendations for improving future management of P. contorta forests for birds are presented.

1374. KEPPIE, D.M. Snow cover and the use of trees by spruce grouse in autumn.
Condor, 1977, 79(3): 382-384

Subject Codes: N/A
BIO: 78033865

1375. KINGERY, H.E. Lodgepole pine forest with aspen.
Am. Birds, 1973, 27(6): 998
Subject Codes: N/A
BIO: 74050554

1376. KOEHLER, G.M., HORNOCKER, M.G., HASH, H.S. Lynx movements and habitat use in Montana.
Can. Field-Nat., 1979, 93(4): 441-442
Subject Codes: N/A
LISC: 487757

Movement of 2 Lynx canadensis were monitored by radio telemetry: an adult male for 7 months, from March to October, and an adult female during January. Home range area for the male was 36 km2. Most locations were in densely stocked stands of lodgepole pine (Pinus contorta) resulting from 1910 fires. Snowshoe hares (Lepus americanus), their principal prey, were also most abundant in these stands.

1377. POWELL, J.M., SADLER, T.S., POWELL, M. Birds of the Kananaskis Forest Experiment Station and surrounding area (of Alberta): an annotated checklist.
Info. Rep., Northern For. Res. Centre, Canada, 1975, No. NOR-X-132: 36 pp.
22 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 514120

Lists a total of 225 bird species known or believed to occur in this part of the eastern Rocky Mountains (where the main forest types are characterized by Picea engelmannii and P. glauca, or by Pinus contorta var. latifolia).

1378. REGELIN, W.L., WALLMO, O.C., NAGY, J., DIETZ, D.R. Effect of logging on forage values for deer in Colorado.
Journal of Forestry, 1974, 72(5): 282-285
6 ref.
Subject Codes: 8.4
CAB: 354763

Reports further results of studies on Odocoileus hemionus forage in clear-felled and uncut strips of Pinus contorta and Picea engelmannii/Abies lasiocarpa forest 15 years after logging. Crude protein content, moisture content and digestibility of the main forage species did not differ significantly between the strips. Production and diversity of forage species was greater in the felled strips, and deer spent more time and ate a greater proportion of their diet there.

1379. ROPPE, J.A., HEIN, D. Effects of fire on wildlife in a lodgepole pine forest.
Southwest Nat., 1978, 23(2): 279-288
Subject Codes: 5.6, 6.3, 6.6
BIO: 66063831

Effects of a subalpine wildfire on populations of wildlife in northcentral Colorado (USA) were investigated 8 yr after the burn. Inventories of bird and mammals were compared on the 190 ha burn with those from an adjacent similar site of lodgepole pine (Pinus contorta) in 1974. Species diversity for birds and small mammals were greater on the burn than in the adjacent lodgepole. Species composition of both birds and mammals was different in the 2 habitats, but population densities of birds and small mammals were not significantly different in the 2 habitats in summer. Mule deer (Odocoileus hemionus) and elk (Cervus canadensis) used the burn more than the lodgepole during winter. Estimated values of total biomass for all birds and mammals were similar for both habitats.

1380. ROTHWELL, R. Nest sites of red squirrels (Tamiasciurus hudsonicus) in the Laramie range of southeastern Wyoming.
J. Mammal. 1979, 60(2): 404-405

Subject Codes: N/A
LISC: 301939

T. hudsonicus nest site characteristics were analyzed in relation to the function of nest placement for 65 nests at 3 sites in the Pole Mountain area. All were constructed in lodgepole pine, average nest height was 5.3 m. Strong preference for certain nest tree locations indicated the immediate area surrounding the nest tree is most important in mity to others, offering protection from weather, providing escape routes and reducing foraging time. The dense stand of a nest site also created a damp, shaded spot for the cache.

1381. SCOTT, V.E., WHELAN, J.A., ALEXANDER, R.R. Dead trees used by cavity- nesting birds on the Fraser Experimental Forest: a case history.
Research Note, Rocky Mountain For. & Range Experiment Stn., USDA Forest Service, 1978, No. RM-360: 4 pp.
7 ref.
Subject Codes: 3.0
CAB: 1431814

Characteristics of snags of Pinus contorta, Abies lasiocarpa and Picea engelmanii with nest holes were surveyed. Frequency of occupation was related to diameter and presence of broken tops. Some 3% of all broken topped trees of d.b.h. over 12" were used for nesting, compared with 5% of all intact trees. It is recommended that dead trees of d.b.h. over 8" be left standing after harvest.

1382. SWENSON, J.E. Osprey Pandion-haliaetus nest site characteristics in Yellowstone National Park, USA.
J. Field Ornithol., 1981, 52(1): 67-69
Subject Codes: N/A
BIO: 22012554

1383. TAYLOR, D.L., BARMORE, W.J. Jr. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks, Wyoming.
Gen. Tech. Rep., Intermountain For. & Range Exp. Stn., 1980, INT-86: 130-145
Subject Codes: N/A
LISC: 566582

The effect of natural fires on avifauna in the 2 parks is reported. Breeding bird populations in burned lodgepole pine or spruce-fir-lodgepole pine forest of various post- fire ages were analyzed. Highest populations and greatest biomass occurred from 5-29 years post-fire. Bird density, species composition, and diversity on moderately burned spruce-fir-lodgepole were more like those on unburned spruce-fir than on other seral stages. Greatest biomass of foliage-insect and timber-searching was greater where the forest canopy had closed. Canopy closure affected avifauna more than fire did.

1384. THOMPSON, L.S. Dwarf shrew Sorex-nanus in north central Montana.
J. Mammal. 1977, 58(2): 248-250
Subject Codes: N/A
BIO: 77079007

1385. URNESS, P.J. Game-range relationships.
Project UTA01001, Utah State Univ., Logan, UTA, 01 Jan 74 to 31 Dec 82
Subject Codes: 3.6, 8.1
CRIS: 0069321

The objectives of this study were to measure production, phenological development, and species composition differences in the understory of mature lodgepole pine stands, natural wet meadows, and on logged and burned-over areas; determine summer diet composition of deer and elk; analyze nutritional value of forage spcies consumed by big game and calculate dietary nutrient contents; predict long-term values of different timber management practices for big game production. Approach: Determinations of understory characteristics will follow accepted sampling techniques which fit into the Forest Service's habitat-type designation system. Deer and elk diet composition will be obtained by use of tractable animals and observation of feeding behaviour. Diet composition will then form the

basis for nutritional analyses to compare relative values of different habitat segments to big game animals. A concept of what is available, consumed, and relative and quantitative value should aid the forest manager in making timber harvest decisions that affect deer and elk in the lodgepole pine ecosystem.

1386. WALLMO, O.C. Response of deer to alternate strip clear cutting of lodgepole pine, spruce and fir timber in Colorado, USA.
US Forest Serv. Research Note RM-141, 1969: 1-4
Subject Codes: N/A
BIO: 69084220

1387. WALLMO, O.C., REGELIN, W.L., REICHERT, D.W. Forage use by mule deer relative to logging in Colorado.
Journal of Wildlife Management, 1972, 36(4): 1025-1033
23 ref.
Subject Codes: N/A
CAB: 275533

1388. WINKLER, D.W., DANA, G. Summer birds of a lodgepole-aspen forest in the southern Warner Mountains, California.
West Birds, 1977, 8(2): 45-62
Subject Codes: N/A
BIO: 78035759

1389. URNESS, P.J. 1985. Managing lodgepole pine ecosystems for game and range values. Pages 197-304 in Lodgepole pine: the species and its management. Symposium proceedings. Pullman, WA.

Variety and production of forage species understory to lodgepole pine forest are usually low and the nutritional value of the dominant forages (mushrooms excepted) tends to be moderate at best. Consequently, wild and domestic ungulate use of these stands as summer range is correspondingly low. Associated nonforested communities, such as dry and wet meadows, generally give lodgepole pine ecosystems their primary forage values in the absence of management. When tree canopies are opened by logging, wildfire, or insect epidemics, however, forage production, nutritional values, and diversity may increase substantially. This effect can last up to 20 years or more before canopy closure again reduces the forage resources for game and livestock. Major benefits occur in the first 10 years; longer if thinning or other managerial action is taken. Where soil depth, fertility, or moisture preclude commercial timber production, particularly on stagnated stands, management for wildlife habitat and livestock grazing may be the best use. Where practical, cheap means to this end (e.g. liberal rail, post, or fuelwood cutting) could supplement scarce habitat or range development funds. Patterned clearing:cover patches should be planned to ensure that increased forage is used since wild ungulates tend to avoid the centers of large openings. Seeding clearcuts to adapted grasses and forbs can greatly increase forage production and seasonal range values.

8.8.2 RECREATION

1390. DALE, D., WEAVER, T. Trampling effects on vegetation of the trail corridors of north Rocky Mountain forests.
Journal of Applied Ecology, 1974, 11(2): 767-772
14 ref.
Subject Codes: 6.5
CAB: 380845

Describes studies made in forests dominated by Abies lasiocarpa, Pinus albicaulis, Pinus contorta or Pseudotsuga menzisii, in central Montana and Wyoming, to show how the width of tracks is related to the numbers of horses or walkers using them, and how ground vegetation adjacent to the tracks is affected.

1391. DESPAIN, D.G. Lodgepole pine ecosystems as producers of recreation. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 278-284
14 ref.
Subject Codes: 6.5
CAB: 757876

Pinus contorta covers large areas in the USA which sustain heavy recreational use. Information on the ability of this species to withstand recreational use is required. Problems in assessing amenity value are briefly discussed.

1392. HERRINGTON, R.B. Recreational problems and opportunities of lodgepole pine. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, pub. 1975: 581-587
Subject Codes: N/A
CAB: 757875

## 8.8.3 FOREST HYDROLOGY

1393. CURRIER, J.B. Water quality effects of logging residue composition from lodgepole pine.
Dissertation Abstracts International, B, 1975, 35(8): 3963-4
Subject Codes: N/A
CAB: 471876

Wood chips from a clear-felled Pinus contorta site (in Colorado), were collected and leached in the laboratory to determine the quantity and composition of the extractable compounds. The leachate consisted primarily of carbohydrates, phenolics and mineral salts. The carbohydrates were rapidly utilized by micro-organisms and removed from solution; consequently the leachate contained mainly phenolics, the principal component being tannin. Mineral salts comprised ca. 15% of the extracted material. Decomposition and percolation tests with the Leachate showed that ca. 50% of the phenolics would decompose within 96 hours. Bioassays with stonefly and mayfly nymphs subjected to concentrations of up to 80 mg/litre of phenolic activity resulted in a maximum of only 20% mortality. It is concluded that, in general, the organic compounds leached from wood chips, bark and needles will not adversely effect water quality.

1394. GARY, H.L. Duration of snow accumulation increases after harvesting clear-strip felling in lodgepole pine in Wyoming and Colorado.
Research Note, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, 1979, No. RM-366: 7 pp.
14 ref., 2 pl.
Subject Codes: 3.2
CAB: 1472482

1395. GOLDING, D.L., STANTON, C.R. Water storage in the forest floor of subalpine forests of Alberta.
Canadian Journal of Forest Research, 1972, 2(1): 1-6
20 ref.
Language: en
Summary Languages: fr
Subject Codes: 2.11
CAB: 121914

Water storage capacity and its relations to other characteristics of the forest floor were determined for three forest types: (a) mature mixed Abies lasiocarpa/Picea engelmannii forest, (b) a part of this forest in which a partial cut of merchantable spruce had been made, and (c) and young Pinus contorta stand;

and for three predominant aspects on Marmot Creek experimental catchment. There were no significant differences between the forest floors of (a) and (b) in water storage capacity (ratio of weight of water held after draining to the dry weight of the forest floor sample), depth of water held after draining, water held per unit thickness of forest floor, or dry weight, although the thickness of the forest floor was 11.36 cm under (a) and 9.84 cm under (b). Compared with (c), the forest floor under (a) and (b) had greater water storage capacity, depth of water held, dry weight, and thickness. There was no significant difference in water held per unit thickness of forest floor, viz. an average of 0.19 cm/cm under (a) and (b) and 0.18 cm/cm under (c). The lower values for (c) are attributed to an intense fire 30 years previously on that area. Regressions are given of: water held on forest floor thickness; weight of water held on dry weight; and water storage capacity on thickness.

1396. HAEFFNER, A.D., LEAF, C.F. Areal snow cover observations in the Central Rockies, Colorado.
USDA For. Serv. Gen. Tech. Rep., Rocky Mountain For. and Range Exp. Stn., 1973, No. RM-5: 15 pp.
16 ref.
Subject Codes: N/A
CAB: 275534

Summarizes observations on snow cover, snowpack depletion and streamflow on six catchments - three in the Fraser Experimental Forest (Pinus contorta and Picea engelmannii/Abies lasiocarpa forest types) and three in the Park Range (including the Populus tremuloides forest type). The data were applied in forecasting streamflow, analyzing water balance and estimating snow-cover duration.

1397. HARRIS, S.A. Annual soil moisture regimes in the rooting zone across the prairie-forest boundary of south-west Alberta.
Journal of Soil Science, 1974, 25(4): 448-460
14 ref.
Subject Codes: 3.6
CAB: 441155

Reports a study in the Front Range of the Rocky Mountains near Calgary showing that vegetation cover was important in controlling soil moisture content. Lodgepole pine extracted more moisture from soil in summer and winter than aspen; least moisture was lost from bare soil. Aspect and parent material were also important variables affecting soil moisture. The permanent (15-bar) wilting point was not well correlated with the actual lower limits of survival of any species examined. Results of experiments in 1968 and 1969 showed that R. buoliana developed successfully in young, even-and-uneven-aged stands of Pinus contorta and P. ponderosa in central Oregon. P. contorta and slow-growing trees of P. ponderosa were most susceptible to damage. P. ponderosa trees 7 ft high appear resistant to damage because of their ability to sustain larval feeding activity without suffering stem distortion. Significantly higher egg mortality was consistently observed on drier study sites E. of the Cascades in Oregon than on sites W. of the Cascades in Washington, where the insect is an established pest of ornamentals. The major physical restraint on the spread of the insect appears to be mortality of overwintering larvae caused by low winter temperatures. Areas in the western pine zone having a high susceptibility to damage by R. buoliana appear to be southern Oregon and California north of 40 deg N. lat.

1398. JOHNSTON, R.S. Soil water depletion by Lodgepole Pine on glacial till.
USDA For. Serv. Res. Note, Intermountain For. and Range Exp. Stn., 1975, No. INT-199: 8 pp.
8 ref.
Subject Codes: N/A
CAB: 556183

In a two-year study on two Pinus contorta sites in Wyoming, soils on clear-felled plots contained 3 to 11 cm more water than adjacent control plots at the end of each summer after felling. The measurements were made, to a depth of 3 m, with a neutron probe, and holes for the access tubes had to be made with a rock drill. Changes in soil water were found to be restricted to the top 2 m of soil.

1399. LOPUSHINSKY, W. Water relations and photosynthesis in lodgepole pine. IN:

Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service. 1973, publ. 1975: 135-153
25 ref.
Subject Codes: N/A
CAB: 769818

A review of available data on transpiration and water conduction, stomatal behaviour, internal water stress, resistance to drought and excess moisture, and photosynthesis in Pinus contorta.

1400. MEIMAN, J.R., DIETRICH, T.L. Hydrology of patch cuts in lodgepole pine.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, 1975, 101,IR1: 41-52
Subject Codes: 7.5
CAB: 604104

Small patch fellings (1200-2500 m2) made in a Pinus contorta forest at 2700 m alt. increased the amount of water potentially available for stream flow by 117 mm/year. Ca. 21% of this increase was the result of increased snow at selected points in the felled areas. The average increase in water content in the top 2 m of soil in the felled areas was 130 mm.

1401. MINORE, D. Seedling growth of 8 northwestern tree species over 3 water tables.
US Forest Serv. Research Note PNW-115, 1970: 1-8
Subject Codes: N/A
BIO: 70067936

1402. MITCHELL, M.E., LOVE, L.D. An evaluation of a study on the effects on streamflow of the killing of Spruce and Pine by the Engelmann spruce beetle.
Arizona Forestry Notes, Northern Arizona University, 1973, No. 9: 20 pp.
5 ref.
Subject Codes: 6.1
CAB: 148863

Presents a reappraisal (including data up to 1969) of a study made in 1955 in western Colorado on stands of Picea engelmannii and Pinus contorta extensively damaged by Dendroctonus engelmannii in 1941-46. It is concluded that the death of the trees has resulted in a continued significant increase in annual stream flow, although it appears that this increase is less than was previously estimated.

1403. REYNOLDS, J.F., KNIGHT, D.H. The magnitude of snowmelt and rainfall interception by litter in lodgepole pine and Spruce-Fir forests in Wyoming.
Northwest Science, 1973, 47(1): 50-60
22 ref.
Subject Codes: N/A
CAB: 217622

Measurements were made of throughfall, hydrological characteristics of the litter (i.e. maximum moisture-holding capacity, drying rates, minimum field moisture content, and interception of snowmelt and rainfall), and total litter weight per unit area in the two forest types in the Nash Fork Creek Watershed. On this basis, some generalizations are made on interception by forest litter on the entire catchment. The results indicate that soil moisture recharge from rainfall during the summer months is probably a rare occurrence in either of the forest types in this region that summer plant growth must depend primarily on one major pulse of soil moisture from snowmelt.

1404. SCHULTZ, R.W. Snowmelt lysimeters perform well in cold temperatures in central Colorado.
USDA For. Serv. Research Note, Rocky Mountain For. and Range Exp. Stn., 1973, No. RM-247: 8 pp.
9 ref.
Subject Codes: N/A
CAB: 249125

Lysimeters were used to measure snow-melt at 3140 m in an even-aged stand of Pinus contorta, average height 14 m, in Colorado. From comparisons with snow-tube measurements it was concluded that the lysimeters gave reliable results. Tests with termistors showed that the polyethylene barriers in the lysimeters had a negligible effect on the temperature profiles and cold content of the snow pack.

1405. STORR, D. Wind-snow relations at Marmot Creek, Alberta.
Canadian Journal of Forest Research, 1973, 3(4): 479-485
6 ref.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 249127

Wind patterns are one of the most important factors to be considered in designing artificial clearings in forested catchments to trap and retain snow and thus make the best possible use of water from melting snow. The author describes a study of wind patterns and snowfall in the Marmot Creek experimental catchment, which comprises 9 km2 at 1585-2800 m alt. in the Alberta mountains and is in its lower half covered with forests of Pinus contorta and Picea spp.

1406. SWANSON, R.H. Local snow distribution is not a function of local topography under continuous tree cover.
Journal of Hydrology, New Zealand, 1970, 9(2): 292-298
Subject Codes: N/A
CAB: 114048

Measurements of snow accumulation were made in the Pinus contorta and mixed aspen cover types in the Deer Creek experimental basin, Alberta, Canada, in two successive months. Snow accumulation showed no relation to aspect, slope, altitude or crown closure that was significant in both months. Results agree with those of a study in the Marmot catchment, and suggest that general guidelines can be specified for managing these cover types for increased water yield, without regard to topography.

## 8.8.4 WATERSHED

1407. GARY, H.L., TROENDLE, C.A. Snow accumulation and melt under various stand densities in lodgepole pine in Wyoming and Colorado.
USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, 1982, Research Note RM-417: 7 pp.
17 ref.
Subject Codes: 7.7
RCA: X1121

High-density forests accumulated less snow than low-density forests. Time of complete melt was prolonged less than a week by high-density forests. A 3-tree-heights-wide clearcut patch increased snow catch about 30% but also decreased snow in the downwind forest by an equivalent amount.

1408. HART, G.E., LOMAS, D.A. Effects of clearcutting on soil water depletion in an Engelmann spruce stand.
Water Resources Research, 1979, 15(6): 1598-1602
16 ref.
Subject Codes: N/A
CAB: 1244821

Soil water depletion was monitored for five growing seasons on 0.4 hectare plots in a mature stand of Engelmann spruce in northern Utah. Three plots were then clearcut and in the first season soil water depletion was 20 to 25 cm less than on an uncut plot. This change, which represents a savings of water previously lost to evapotranspiration is considerably greater than reported for comparable studies in aspen and lodgepole pine. The effects of clearcutting on soil water depletion are expected to persisst for as many as 50 years. In the first winter after

cutting, peak snow water equivalent in the clearcut plots averaged 91 cm, or 31 cm greater than for the uncut control plots.

1409. HILLMAN, G.R., GOLDING, D.L. Forest floor characteristics of Marmot and Streeter experimental watersheds, Alberta.
Info. Rep., Northern For. Res. Centre, 1981, No. NOR-X-234: iii + 22 pp
30 ref., 1 pl.
Language: en
Summary Languages: fr
Subject Codes: N/A
CAB: 1514689

Water-holding capacity was investigated in mature (1) and partially felled (2) Picea engelmanii/Abies lasiocarpa and 30-yr-old Pinus contorta (3) forests on the Marmot Creek watershed, and in Populus tremuloides/P. balsamifera (4) forest on the Streeter Creek watershed. Water storage was significantly correlated with forest floor litter thickness and dry weight. As a result of this, more water was held under (1) and (2) than under (3). The forest floor under (4) held less water than (1) and (2), but more than (3). From authors' summary.

1410. HOOVER, M.D. Watershed management in lodgepole pine ecosystems. IN: Management of Lodgepole Pine Ecosystems.
USA, Washington State University Cooperative Extension Service, 1973, publ. 1975: 569-580
8 ref.
Subject Codes: N/A
CAB: 757469

A review of the hydrology, protection and restoration of catchment areas and the improvement of water yield in relation to forest management in Pinus contorta ecosystems.

1411. LEAF, C.F. Watershed management in the Rocky Mountain subalpine zone: the status of our knowledge.
USDA For. Serv. Res. Paper, Rocky Mountain For. and Range Exp. Stn., 1975, No. RM-137: 31 pp.
77 ref.
Subject Codes: N/A
CAB: 556164

Describes the management of catchments in the sub-alpine zone of Wyoming, Colorado and New Mexico (a zone characterized by stands of Pinus contorta, Picea engelmannii/Abies lasiocarpa, Pseudotsuga menziesii and Populus tremuloides), and considers the forest hydrology of the area in detail. In particular the author reviews and discusses (1) field studies on the effect of different catchment management practices on the accumulation and melting of snow, and on subsequent run-off, and (2) simulation models for predicting the hydrological effects of logging and modification of the weather. Relevant literature is reviewed, requirements for further research are emphasized, and recommendations are made for applying principles of catchment management in land-use planning.

1412. STOTTLEMYER, J.R. RALSTON, C.W. Nutrient balance relationships for watersheds of the Fraser Experimental Forest. IN: Proceedings of the 3rd North American Forest Soils Conference, North Carolina State Univ, Raleigh, August, 1968. XIV + 527 p.
Oregon State Univ. Press, Corvallis, Oregon, USA, 1971: 359-382
Subject Codes: 3.3
BIO: 71033608

1413. SWANSON, R.H. 1985. Managing Lodgepole pine ecosystems as watersheds. Pages 305-313 in Lodgepole pine: the species and its management. Symposium proceedings. Washington State University, Pullman, WA.

The lodgepole pine forest type occupies portions of the Colorado, Columbia, Fraser, Missouri and Saskatchewan river headwaters in Canada and the United States. The onsite needs of fish for habitat and clean water, as well as the needs of downstream water users must be considered during any forestry operations in these watersheds. Clear-cutting of lodgepole pine forests alters streamflow by localizing snow accumulation and reduction evapotranspiration.

The physical features of a managed forest that most affect its water-yielding characteristics are tree- cleared edge and clear-cut size. A 50:50 pattern of treed and clear-cut patches no larger than 2-6 tree heights across in any direction should produce maximum water yield from immature, stagnant, or mature lodgepole pine forests anywhere within its range. The Northern Forest Research Centre has produced an interactive FORTRAN program for the hydrology portion of the USFS WRENSS procedure. This simple-to-use procedure estimates the annual water yield change that will occur under a wide variety of silvicultural practices.

1414. TROENDLE, C.A., LEAF, C.F. Effects of timber harvesting in the snow zone on volume and timing of water yield. IN: Int. West Watershed Symp., 1980, April 30, Spokane, WA.
Wash. State Univ.. 1980: 231-243
Subject Codes: N/A
RCA: X1210

8.8.5 AGRICULTURE

1415. BASILE, J.V., JENSEN, C.E. Grazing potential on lodgepole pine clearcuts in Montana.
U.S. Dep. Agric. For. Serv., Res. Pap. INT-98, Intermt. For and Range Exp. Stn., Ogden, Utah. 1971: 11 pp.
Subject Codes: 8.8.1
RCA: X1101

Production of understory vegetation following clearing of lodgepole pine (Pinus contorta) is described by multiple regression sets that identify combinations of environmental factors affecting understory vegetation production.

1416. CLARK, M.B., MCLEAN, A. Compatibility of grass seeding and coniferous regeneration of clearcuts in the south central interior of British Columbia.
Res. Notes, B.C. Forest Service, 1978, 83: 25 pp.
Subject Codes: 7.1
LISC: 406197

The effects of sowing non-rhizomatous species of domestic grasses on clearcuts and the subsequent grazing of these on the establishment, survival and growth of coniferous tree species, primarily lodgepole pine (Pinus contorta var. latifolia), was investigated. Generally, there is compatibility between trees and grass provided that cooperation exists between managers and users of the resources. The degree of forage utilization and period of time when, and over which, the forage is utilized is the most critical factor in the overall question of tree-grass compatibility. Exceptions to many situations can and do occur, therefore guidelines applicable to specific situations are unreliable and it is necessary to take an holistic approach to the subject of tree-grass compatibility. One can only assume that certain interactions will occur if specific recommendations are followed.

1417. MAJAK, W., PARKINSON, P.D., et al. The effect of light and moisture on columbia milkvetch toxicity (to cattle) in lodgepole pine forests.
J. Range Manage., 1977, 30(6): 423-427
Subject Codes: N/A
BIO: 15000113

1418. MUTCH, W.E.S. Combined land use at Fassfern.
International Tree Crops Journal, 1980 1(1): 49-60
2 ref.
Language: en
Summary Languages: fr, es
Subject Codes: N/A
CAB: 1343564

Joint planning of forestry and agriculture on a 2000-ha estate in the western Highlands of Scotland has increased livestock production from 200-300 lambs and 30

calves in 1952 to 500 lambs and 33 calves in 1978 on 20% of the area. This has been achieved by improved pasture and livestock management and large investment. The remaining 1600 ha have been afforested since 1955 with Sitka spruce, Scots pine, lodgepole pine, larch (Larix leptolepis, l X eurolepis) and Douglas-fir. The interdependence of farm and forest is illustrated by the occasional use of forestry workers on the farm, the sharing of specialist machinery, and the use of plantations for shelter and grazing in winter. Employment has increased by 5-6 times. From author's summary.

# AUTHOR INDEX