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The spruce beetle *Dendroctonus rufipennis* (Kirby): An annotated bibliography 1885 - 1987

D.A. Linton and L. Safranyik

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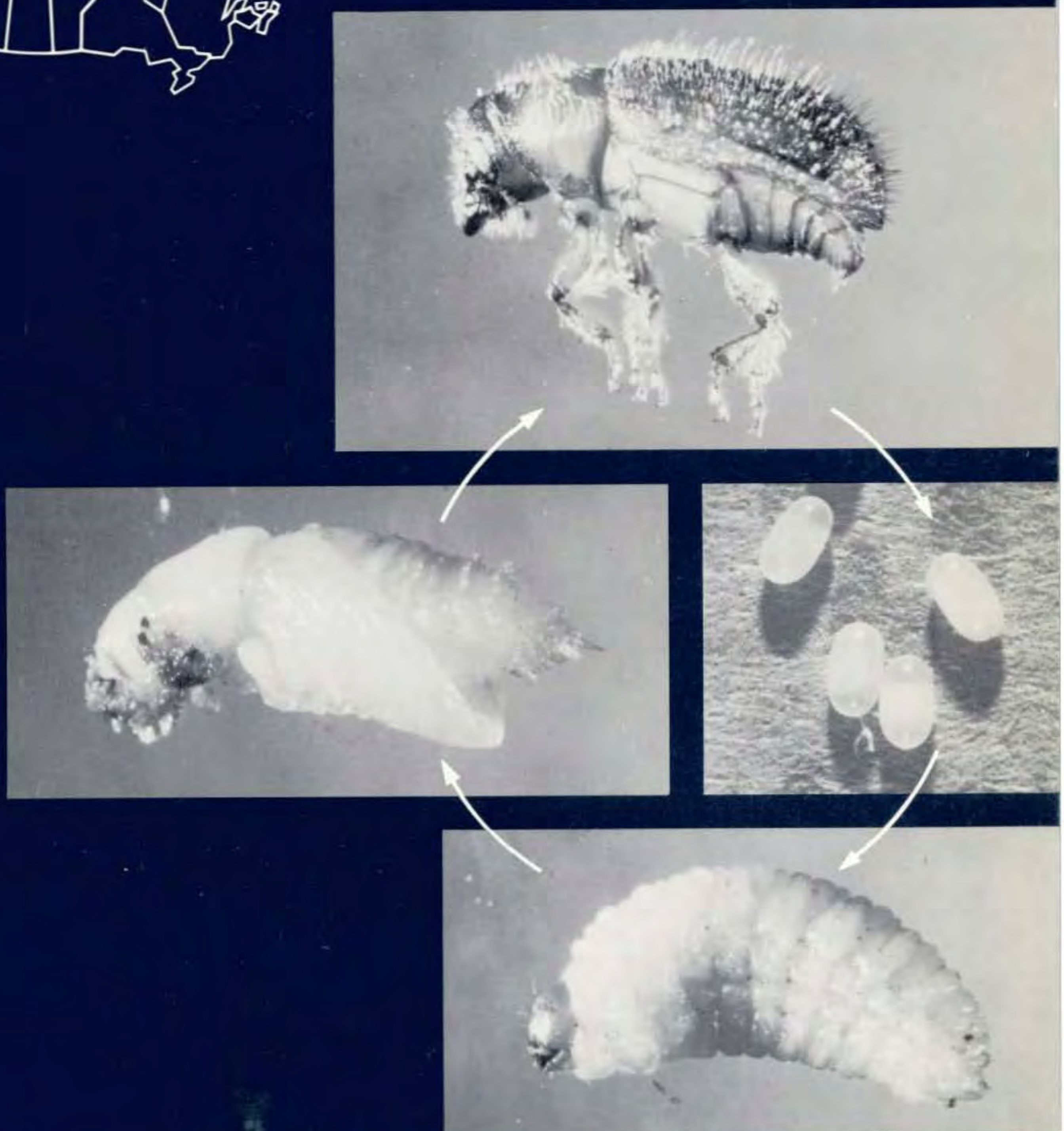

The Spruce Beetle

Dendroctonus rufipennis (Kirby):

An annotated bibliography 1885-1987

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Abstract

Published literature dealing with the taxonomy, biology, ecology and management of the spruce beetle, *Dendroctonus rufipennis* (Kirby), has been briefly annotated. This bibliography contains 311 references, with author and subject indexes. Its purpose is to provide easy access to published information on this destructive insect.

Résumé

Brèves annotations d'articles traitant du dendroctone de l'épinette, *Dendroctonus rufipennis* (Kirby), du point de vue de la taxinomie, de la biologie, de l'écologie et de la lutte contre cet insecte. Cette bibliographie comporte 311 références, ainsi que des index des auteurs et des sujets. Elle a pour but de faciliter l'accès à la documentation qui existe sur cet insecte destructeur.

Foreword

The spruce beetle, *Dendroctonus rufipennis* (Kirby) (Coleoptera: Scolytidae), is indigenous to the spruce (*Picea* sp.) forests of North America and is the most destructive pest of mature stands in western Canada. Normally, the beetle breeds in logging residue, windfelled, cut, decadent and weakened trees, and all recorded outbreaks have followed population buildups in such host materials. Successful attacks usually kill the tree. Periodic outbreaks cause widespread killing of apparently healthy trees, especially following years with extensive windfall. For example, from 1961 to 1965 an outbreak in white spruce (*P. glauca* (Moench) Voss) forests in central British Columbia occurred over 243 000 ha and an estimated 14.1 million m^3 of timber was lost.

Due to the large impact of this beetle on timber production, other resource values, stand development and dynamics, and forest management, there is a continuing need for information on beetle biology and habits, interaction with the host, and management practices to reduce losses. This annotated bibliography was prepared as part of a research program to develop management guidelines for the spruce beetle. The bibliography is based mainly on references in the files of the authors, their colleagues, and the library at the Pacific Forestry Centre, and additional references obtained from *Biological Abstracts*, *Forestry Abstracts*, and *The Review of Applied Entomology*. The Dialog Information Services Inc. databases, Agricola, CAB Abstracts and Biosys Previews were also searched. The literature published up to October 31, 1987 is included.

The bibliography has been restricted to published reports and some theses, most of which are readily available. Prior to 1963, several species of spruce-inhabiting *Dendroctonus* were recognized: *D. engelmanni* Hopk., *D. rufipennis* (Kirby), *D. similis* Le Conte, *D. piceaperda* Hopk., *D. obesus* (Mannerheim), and *D. borealis* Hopk. Wood (1963) synonymized the six species under *D. obesus* and in 1969 he established *D. rufipennis* as the correct name. References pertaining to all of these six former species are included in the bibliography.

The references have been arranged alphabetically by author. There are two major indexes for author and subject, as well as three minor indexes for theses, geographical distribution, and pesticides.

Annual station or departmental reports, and similar publications are not included, unless research information is presented that was not found elsewhere in separate articles. Likewise, survey reports or biological evaluations are not included unless they were deemed to contain important historical or unique biological information.

Acknowledgement

We thank Ms. Marlene M. Mitchell of the Pacific Forestry Centre library for her patience and determination in locating some of the papers we have listed.

Citations

1. **Alexander, R.R. 1973.**

   Partial cutting in old-growth spruce-fir.

   U.S. For. Serv. Res. Pap. RM-110, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 16 p.

   Partial cuts can scatter windfalls throughout stands which prevent salvage and provide breeding material for beetles. This paper identifies such high beetle hazard situations.

2. **Alexander, R.R. 1986.**

   Silvicultural systems and cutting methods for old-growth spruce-fir forests in the central and southern Rocky Mountains.

   U.S. For. Serv. Gen. Tech. Rep. RM-126, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 33 p.

   This report gives guidelines for developing the cutting practices needed to convert old-growth forests to managed stands. Stand conditions, succession, windfall risk, insect and disease susceptibility are considered. The recommended practices are designed to integrate harvesting with other uses.

3. **Amman, G.D. 1958.**

   A comparative study of the methods of censusing woodpeckers in spruce-fir forests in Colorado.

   M.S. thesis. Colorado State Univ., Fort Collins. 125 p.

   The author compares four methods of censusing and the effects of: number of nest trees, seasons, weather, behavior of birds, and the presence of spruce beetle infestation.

4. **Amman, G.D.; Baldwin, P.H. 1960.**

   A comparison of methods for censusing woodpeckers in spruce-fir forests of Colorado.

   Ecology 41: 699-706.

   The distribution of insects and control of the insect population by woodpeckers is discussed, and methods for censusing woodpeckers are compared. It is concluded that the variable-width-strip method is best.

5. **Anderson, R.F. 1960.**

   Inner-bark boring insects.

   Pages 200-271 in *Forest and shade tree entomology. New York, Wiley. 428 p.*

   Along with textbook description of the inner-bark boring insects and associated tree damage, the author recommends using ethylene dibromide (3 lb./5 gal. water, or 1.5 lb./5 gal. oil) as bole spray for control on infested trees.

6. **Atkins, M.D. 1966.**

   Behavioral variation among scolytids in relation to their habitat.

   Can. Entomol. 98: 285-288.

   A comparative discussion of scolytid behavior.

7. **Baker, Bruce H.; Kemperman, J.A. 1974.**

   Spruce beetle effects on a white spruce stand in Alaska.

   J. For. 72: 423-425.

   There was a 64.6% mortality among spruce greater than 5″ (13 cm) dbh, but survival was greater in small diameter trees. Birch was dominant in the residual stand.

8. **Baker, W.L. 1972.**

   Eastern forest insects.

   U.S. For. Serv. Misc. Publ. 1175

   Eastern forest insects are briefly described along with the damage they do and their frequency of occurrence.

9. **Balch, R.E. 1934.**

   Imported forest insects.

   Pulp Pap. Mag. Can. 35: 679-680. (new series)

   A spruce beetle outbreak follows major defoliation of white spruce by *Diprion polytomum* on the Gaspé peninsula.

10. **Balch, R.E. 1942.**

    On the estimation of forest insect damage, with particular reference to *D. piceaperda* Hopk.

Pulp Pap. Mag. Can. 43: 900-905.

Forest insects destroy trees, modify forest composition and increase fire hazards.

11. Baldwin, Paul H. 1960.

Overwintering of woodpeckers in bark beetle-infested spruce-fir forests of Colorado.

Pages 71-84 in *Proc. XII International Ornithological Congress, Helsinki, 1958.*

Northern three-toed, downy, and hairy woodpeckers aggregate in winter and feed on bark beetle larvae, then disperse during summer breeding season.

12. Baldwin, Paul H. 1968.

Woodpecker feeding on Engelmann spruce beetle in windthrown trees.

U.S. For. Serv. Res. Note RM-105, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

In an area where woodpeckers were plentiful, the birds reduced the beetle population by 70-79%.

13. Baldwin, Paul H. 1969.

Predator-prey relationships of birds and spruce beetles.

Forty-seventh annual conference of North Central States Entomologists. Pages 90-99 in *Proc. North Cent. Branch Am. Assoc. Econ. Entomol. 23 pt. 2 [1968].*

The proceedings provide a list of birds that feed on spruce beetles and show that passerine birds account for a 24-32% reduction in beetle population. Woodpecker abundance varied in the autumn with beetle availability and nesting increased with a rising beetle population. Beetle density was associated with the woodpeckers' efficiency as predators. Woodpecker feeding accounted for up to an 84% reduction when there were 160 000 beetles per acre.

14. Beckwith, R.C. 1972.

Key to adult bark beetles commonly associated with white spruce stands in interior Alaska.

U.S. For. Serv. Res. Note PNW-189, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 6 p.

The author gives a dichotomous key to the bark beetles, as well as schematic drawings.

15. Beckwith, R.C. 1972.

Scolytid flight in white spruce stands in Alaska.

Can. Entomol. 104: 1977-1983.

The spruce beetle, *Ips* spp., and *Trypodendron lineatum* flew in late May and early June while other scolytids flew in June and July. Flight was about two weeks earlier in warmer, central Alaska than on the coast.

16. Beckwith, R.D.; Wolff, J.O.; Zasada, J.C. 1977.

Bark beetle response to clearcut and shelterwood systems in interior Alaska after whole tree logging.

U.S. For. Serv. Res. Note PNW-287, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 7 p.

Shelterwood area scolytid populations increased five times in the first year, and three times in the second, while clearcut area populations (mainly *Trypodendron*) decreased over 3 years. Spruce beetle numbers remained low in all areas.

17. Belyea, R.M.; Prebble, M. 1951.

Mortality of white spruce, Lake Nipigon area.

Can. Dept. Agric. Sci. Serv. Div. For. Biol. Bi-mon. Prog. Rept. 7. p 2.

D. piceaperda found in lower boles of dying trees defoliated by spruce budworm. Investigation showed decreased host vigor over past 25-30 years. It was concluded that the beetle attack was not very aggressive, but due mainly to low host vigor plus weakening from defoliation.

18. Bentz, B.J.; Stock, M.W. 1986.

Phenetic and phylogenetic relationships among ten species of *Dendroctonus* bark beetles (Coleoptera: Scolytidae).

Ann. Entomol. Soc. Am. 79: 527-534.

The genetic relationships among 10 species of bark beetles were studied using 18 gene loci. Groupings generally correspond to anatomical, cytogenetic and behavioral groupings with *D. rufipennis* (Kirby) amongst the most primitive species.

19. Betcher, B. 1982.

Crestbrook attacks Spruce Beetles.

Can. For. Ind. News. (reprints of articles in Creston Valley Advance, Jan. 1982)

The author gives a history of outbreaks on company holdings and discusses Crestbrook's efforts both to control the beetles and to salvage infested and dead material.

20. Bethlahmy, N. 1974.

More streamflow after a bark beetle epidemic.

J. Hydrol. 23: 185-189.

Records for two valleys in which the spruce suffered heavy mortality from spruce beetle show major increases in streamflow after the epidemic.

21. Bethlahmy, N. 1975.

A Colorado episode: Beetle epidemic, ghost forests, more streamflow.

Northwest Sci. 49: 95-105.

Water flow in two large watersheds is substantially higher than normal for at least 25 years after the forests are killed.

22. Blackman, M.W. 1950.

The eastern spruce beetle.

Pages 318-319 in *F.C. Craighead, ed. Insect enemies of eastern forests. U.S. Dept. Agric. Misc. Publ. 657. 679 p.*

A brief description of *D. piceaperda* and the damage it causes is given, along with a short history of spruce beetle outbreaks in eastern North America.

23. Bloch, D. 1946.

Three billion feet lost to beetle hordes.

Timberman 48: 102-103.

This popular article describes spruce losses from 1940 to 1946 in Colorado, and claims that beetles had attacked lodgepole pine in one area.

24. Bloch, D. 1950.

To save the trees beyond; details of battle being waged to save a portion of Colorado's valuable stand of Engelmann spruce from attack by spruce bark beetles.

Timberman 51: 78-84.

The operational use of orthodichlorobenzene 1:6 in diesel oil on infested trees is described.

25. Bloch, D. 1951.

Crucial year for beetle control.

Green Thumb 7: 24-26 Abstract: (Bibl. Agr. 15: 5695)

Extensive spruce beetle control work done in Colorado is outlined, where orthodichlorobenzene 1:6 in diesel oil was sprayed on 500 000 trees to kill the 1949 brood.

26. Borden, J.H. 1982.

Aggregation pheromones.

Pages 74-139 in *J.B. Mitton and K.B. Sturgeon, eds. Bark beetles in North American conifers. Austin, Univ. of Texas Press. 527 p.*

The author gives a detailed description of pheromones and their actions on all phases of beetle dispersal and attack, and includes a list of species and their known pheromones.

27. Boss, G.D.; Thatcher, T.O. 1970.

Mites associated with *Ips* and *Dendroctonus* in southern Rocky Mountains with special reference to *Iponemus truncatus* (Acarina: Tarsonemidae).

U.S. For. Serv. Res. Note RM-171, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 7 p.

No mites were found to be predatory on any stage of *Dendroctonus*, and beetles were used only for dissemination.

28. Bright, D.E. 1976.

The bark beetles of Canada and Alaska. Part 2. The insects and arachnids of Canada.

Res. Branch, Can. Dept. Agric. Publ. 1576. Biosystematics Res. Inst., Ottawa, Ont., 241 p.

A description of bark beetles, their habits and their distribution in Canada.

29. Bue, C.D.; Wilson, M.T.; Peck, E.L. 1955.

Discussion of "The effect on streamflow of the killing of spruce and pine by the Engelmann spruce beetle" by L.D. Love.

Trans. Am. Geophys. Union 36: 1087-1089.

The authors refute Love's (1955) conclusion that streamflow increased due to spruce beetle killing of forest, and believe instead that the effect may be due to climatic trends.

30. Buell, J.H. 1953.

Problems facing forest management in the central Rocky Mountains.

U.S. For. Serv. Rocky Mt. For. and Range Exp. Stn. Pap. 13, Fort Collins, Colo. 5 p.

This paper describes spruce beetle damage in Colorado.

31. Buell, J.H. 1954.

Problems facing forest management in the central Rocky Mountains.

J. For. 52: 163-165.

Spruce beetle damage in Colorado is discussed.

32. Buffam, P.E. 1971.

Spruce beetle suppression in trap trees treated with cacodylic acid.

J. Econ. Entomol. 64: 958-960.

Silvisar 510® was injected in hatchet frills, and various treatment timings before beetle flights were compared. An evaluation was made after 12-13 months, and it was found that the best treatment was 1/2 strength Silvisar injected four weeks before peak flight with treated trees felled two weeks before peak flight.

33. Buffam, P.E.; Lister, C.K.; Stevens, R.E.; Frye, R.H. 1973.

Fall cacodylic acid treatments to produce lethal traps for spruce beetles.

Environ. Entomol. 2: 259-262.

Half-strength Silvisar 510® was most effective on trees treated in September and October and felled one month later.

34. Buffam, P.E.; Yasinski, F.M. 1971.

Spruce beetle hazard reduction with cacodylic acid.

J. Econ. Entomol. 64: 751-752.

Spruce trees along 10 miles of trail were treated before felling to prevent build-up of spruce beetle. The attack density on treated trees was similar to untreated windfall but essentially no brood established; whereas windfalls had more than 100 brood per sq. ft.

35. Cahill, D.B. 1975.

Impact of Engelmann spruce beetle on spruce forests of the Colorado Flattops.

Entomological Society of America North Central Branch. Proceedings North Central Branch Entomological Society of America, 29th Annual Meeting, Fifty-third Annual Conference of the North Central States Entomologists, Des Moines, Iowa, April 1974. Proc. Annu. Meet. North Cent. Branch Entomol. Soc. Am. 29, 204 p.

The study area was devastated during the period 1939-51 and $120 million dollars were lost in timber values. The impact on other resources is also discussed.

36. Cahill, D.B. 1977.

Net impact of spruce beetle outbreak on White River National Forest, 1939-1951.

U.S. For. Serv. Rocky Mt. Reg. Rep. 1977. Fort Collins, Colo. 18 p.

A survey of lost forest resources.

37. Cahill, J.M. 1980.

Preliminary lumber recovery for dead and live Engelmann spruce (*Picea engelmannii*).

U.S. For. Serv. Res. Note PNW 365, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 11 p.

Compares lumber recovery, grade distributions and log values for spruce dead 20 years to live trees.

38. Callaham, R.Z.; Shifrine, M. 1960.

The yeasts associated with bark beetles.

For. Sci. 6: 146-154.

A summary of literature to date that brings together scattered, inaccessible references. New information on taxonomy and the growth of yeasts at different temperatures is also given.

39. Carhart, A.H. 1949.

Mass murder in the spruce belt.

Am. For. 55: 14-15, 41-42.

Describes the large-scale damage done by spruce beetle on the east slope of the Rockies.

40. Chamberlin, W.J. 1939.

The bark beetles and timber beetles of North America, north of Mexico.

Oregon State Univ. Coop. Assoc., Corvallis, Oreg. 513 p.

A taxonomic description of beetles.

41. Chamberlin, W.J. 1958.

The Scolytoidea of the Northwest.
Oregon, Washington, Idaho and B.C.

Oregon State Monogr. Studies in Entomology, No. 2, Oregon State College, Corvallis. 208 p.

A key and description of the scolytidea of the northwest, including their life cycle and habits.

42. Chansler, J.F. 1960.

Some factors influencing the flight performance of the Engelmann spruce beetle.

M.F. thesis, Univ. of Michigan, Ann Arbor. 41 p.

Spruce beetle flight ability is variable among individuals. Lab tests indicate that some beetles can fly more than 76 miles nonstop. Many beetles fly repeatedly for short periods totalling more than one hour with initial speeds of 256 feet (78 m) per minute. (Schmidt and Frye 1977).

43. Chansler, J.F.; Pierce, D.A. 1966

Bark beetle mortality in trees injected with cacodylic acid (herbicide).

J. Econ. Entomol. 59: 1357-1359.

A direct injection of cacodylic acid into the sap stream near ground level shortly after attack — but before most eggs hatched — caused a significant reduction of the brood.

44. Chapman, J.A. 1972.

Ommatidia numbers and eyes in scolytid beetles.

Ann. Entomol. Soc. Am. 65: 550-553.

A discussion of eye function and its effect on the behavior of *D. rufipennis* and five other species.

45. Chapman, J.A. 1957.

Flight muscle change during adult life in the scolytidae.

Can. Dep. Agric. For. Biol. Div. Bi-Mon. Prog. Rept. 13: 3.

This report shows that flight muscles of adults reduced in size after the initiation of gallery activity.

46. Chapman, J.A.; Dyer, E.D.A. 1969.

Cross attraction between the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.) and the spruce beetle (*D. obesus* (Mann.)).

Can. For. Serv. Bi-Mon. Res. Notes 25: 31.

Although these species normally occupy distinct habitats, strong cross attraction does occur, and the Douglas-fir beetle will readily attack spruce logs.

47. Chrystal, R.N. 1915.

Forest insect conditions in Stanley Park, Vancouver, B.C.

7th Annu. Rep. Que. Soc. Prot. Plants, 1914-1915.

The presence of spruce beetles in Sitka spruce in Stanley Park is noted.

48. Chrystal, R.N. 1916.

Forest insect investigations

Agric. Gaz. Can. 3: 796.

The presence of spruce beetles in Sitka spruce in Stanley Park, Vancouver, B.C., is noted for the second year.

49. Churcher, J.J. 1984.

Detection of spruce beetle (*D. rufipennis*) infestations using aerial photographs.

M.S. thesis. Faculty of Forestry, Univ. of British Columbia, Vancouver.

(Copy not received)

50. Collis, D.; Harris, J.W.E. 1970.

Status of spruce beetle in British Columbia, 1969.

Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-40. Victoria, B.C. 22 p.

Severe problems with spruce beetles persist, and it is recommended that cutting priority should be given to mature and over-mature stands.

51. Comer, F.G. 1949.

Logging damage in salvaging beetle-killed spruce stands.

M.S. thesis. Colorado State Univ., Fort Collins.

(copy not received)

52. Cottrell, C.B. 1978.

Spruce Beetle in British Columbia.

Can. For. Serv., Pac. For. Res. Cent. For. Pest Leafl. 13. Victoria, B.C.

This leaflet gives a brief description of the insect and its life history, along with information on the damage it does, its hosts, and detection techniques that use bark symptoms and foliage color. Prevention of outbreaks, and natural and applied controls are also mentioned.

53. Cottrell, C.B.; Unger, L.S.; Fiddick, R.L. 1979.

Timber killed by insects in British Columbia 1971-1975.

Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-189, Victoria, B.C., 31 p.

This report contains data on the number and volume of timber killed by all insects. Scolytids are seen to be the major cause of tree mortality, mainly in spruce-fir stands.

54. Coulson, R.N.; Witter, J.A. 1984.

Phloem boring insects.

Pages 509-554 in *Forest entomology: ecology and management. New York, Wiley, 670 p.*

A brief description of beetles, beetle damage and hosts.

55. Craighead, F.C. 1925.

The *Dendroctonus* problems.

J. For. 23: 340-354.

A general overview of problems in the United States which describes the killing of overmature spruce in the eastern U.S. that left fir susceptible to budworm.

56. Craighead, F.C. 1930.

An annotated list of the important North American forest insects.

U.S. Dept. Agric. Misc. Publ. 74. 30 p.

This brief resumé of American control efforts also lists insects and the primary geographic regions of their activity.

57. Craighead, F.C. 1950.

Insect enemies of eastern forests.

U.S. Dept. Agric. Misc. Publ. 657. 697 p.

This document contains a short description of the spruce beetle and beetle damage in the East plus similar articles on many other forest pests.

58. Dahlsten, D.L. 1982.

Relationships between bark beetles and their natural enemies.

Pages 140-182 in *J.B. Mitton and K.B. Sturgeon, eds. Bark beetles in North American conifers. Austin, Univ. of Texas. 527 p.*

The relationships between bark beetles and their associated predators and parasites are described.

59. Davidson, R.W. 1951.

A deterioration problem in beetle-killed spruce in Colorado.

Phytopathology 41: 560.

Eleven years after the spruce trees were killed, decay was present in up to 50% of the standing stems at heights of 2-3 feet, and partially decayed trees were subject to windfall.

60. Davidson, R.W. 1954.

Species of Ophiostomataceae associated with Engelmann spruce bark beetle.

Phytopathology 44: 485.

Four species adapted to insect dissemination.

61. Davidson, R.W. 1955.

Wood-staining fungi associated with bark beetles in Engelmann spruce in Colorado.

Mycologia 47: 58-67.

A description of the fungi associated with bark beetles.

62. Davidson, R.W. 1958.

Additional species of Ophiostomataceae from Colorado.

Mycologia 50: 661-670.

Ceratocystis is associated with bark beetles in Engelmann spruce.

63. Davis, J.M.; Nagel, R.H. 1956.

A technique for tagging large numbers of live adult insects with radioisotopes.

J. Econ. Entomol. 49: 210-211.

The authors discuss a technique for applying a gamma emitter to aid in the location of tagged beetles after dispersal.

64. Downing, G.L. 1957.

The recent history of destructive forest insect activity in Alaska.

U.S. For. Serv. For. Insect Surv. Rep. No. 1. Alaska For. Res. Cent. Juneau, Alaska, 4 p.

This report gives a history of the locations, and the size of insect epidemics back to 1920 in Alaska.

65. Downing, G.L. 1957.

The recent history of destructive forest insect activity in Alaska.

Pages 111-116 in *Science in Alaska. Proc. 18th Alaska Sci. Conf. Sept. 10-13, 1957, Anchorage, Alaska. Alaska Div., Am. Assoc. Adv. Sci., Washington, D.C.*

A history of the location and size of infestations back to 1920 in Alaska.

66. Dunn, M.B. 1936.

The function of wood-boring insects in the development of the forest.

Ont. Entomol. Soc. Rep. 66: 8-11.

Although they are not true borers, moderate numbers of the insects mentioned here maintain a regular minor mortality rate of over-mature, weak or injured timber, thus providing for more rapid development of desirable stock.

67. Dyer, E.D.A. 1969.

Influence of temperature inversion on development of spruce beetle, *Dendroctonus obesus* (Mannerheim) (Coleoptera: Scolytidae).

J. Entomol. Soc. B.C. 66: 41-45.

Due to temperature inversion, broods at higher elevations matured in one season, but broods in valley bottoms required two seasons to mature. Temperatures high enough to allow for development in one season can cause the attacking population to double.

68. Dyer, E.D.A. 1970.

Larval diapause in *Dendroctonus obesus* (Mannerheim) (Coleoptera: Scolytidae).

J. Entomol. Soc. B.C. 67: 18-21.

Fluctuating high and low temperatures during development were required to cause late-stage larvae to enter diapause, which would result in a 2-year life cycle in the natural state.

69. Dyer, E.D.A. 1973.

Spruce beetle aggregated by the synthetic pheromone frontalin.

Can. J. For. Res. 3: 486-494.

Spruce beetles were attracted to healthy spruce trees and were induced to attack using frontalin. Some baited trees were killed, but many resisted attack.

70. Dyer, E.D.A. 1975.

Frontalin attractant in stands infested by the spruce beetle, *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

Can. Entomol. 107: 979-988.

Frontalin was applied to trees in lines in stands. Attacks on trees were concentrated within strips 2 chains (40.2 m) wide on either side of the line.

The predator *Thanasimus undatulus* (Say) was also attracted.

71. Dyer, E.D.A.; Chapman, J.A. 1971.

Attack by the spruce beetle induced by frontalin or billets with burrowing females.

Can. For. Serv. Bi-Mon. Res. Notes 27: 10-11.

The pheromone frontalin triggered the process of mass attack, but was not as attractive as females in billets.

72. Dyer, E.D.A; Hall, P.M. 1977.

Factors affecting larval diapause in *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

Can. Entomol. 109: 1485-1490.

Daily degree-days must be less than 9°C above the development threshold of 6.1°C to induce diapause. Induction of diapause occurred no later than third instar. Field temperatures determine whether beetles have a one or two-year life cycle.

73. Dyer, E.D.A.; Hall, P.M. 1977.

Effect of anti-aggregative pheromones 3,2-MCH and trans-verbenol on *Dendroctonus rufipennis* attacks on spruce stumps.

J. Entomol. Soc. B.C. 74: 32-34.

The pheromones 3,2-MCH and trans-verbenol reduced the attacks on treated stumps, but not enough to be of value for control.

74. Dyer, E.D.A.; Hall, P.M. 1980.

Effect of the living host tree (*Picea*) on the response of *Dendroctonus rufipennis* (Coleoptera: Scolytidae) and a predator *Thanasimus undatulus* (Coleoptera: Cleridae) to frontalin and seudenol.

Can. Entomol. 112: 167-171.

Frontalin was more effective than seudenol on host trees, but suedenol attracted more beetles to non-host trees. *Thanasimus* was more attracted by frontalin.

75. Dyer, E.D.A.; Hall, P.M. 1983.

Effect of high density frontalin baiting on attack distribution of *Dendroctonus rufipennis* in spruce plots.

J. Entomol. Soc. B.C. 80: 14-19.

Intensive baiting with frontalin resulted in 23-63% of potentially resistant standing trees being attacked in the treated plots vs. 1% in untreated plots. All fresh downed material was attacked, but at a lower density in the treated plots. Frontalin caps on the ground failed to induce an attack on standing trees.

76. Dyer, E.D.A.; Hall, P.M.; Safranyik, L. 1975.

Numbers of *Dendroctonus rufipennis* (Kirby) and *Thanasimus undatulus* Say at pheromone-baited poisoned and unpoisoned trees.

J. Entomol. Soc. B.C. 72: 20-22.

Poisoned and baited trees captured four times as many spruce beetles and more clerids than did unpoisoned baited trees.

77. Dyer, E.D.A.; Hodgkinson, R.S., editors. 1981.

Spruce beetle management seminar and workshop. Proceedings in abstract.

Pest Manage. Rep. No. 1. B.C. Minist. For. Victoria, B.C. 16 p.

Various authors discuss the biology, management, current status, harvesting policy, and survey and control techniques for spruce beetles, plus associated insects and current research.

78. Dyer, E.D.A.; Lawko, C.M. 1978.

Effect of seudenol on spruce beetle and Douglas-fir beetle aggregation.

Can. For. Serv. Bi-Mon. Res. Notes. 34: 30-31.

Seudenol plus alpha-pinene on spruce attracted mainly male spruce beetles plus Douglas-fir beetles. Neither seudenol or ethanol enhanced frontalin attraction for spruce beetle, but they did enhance attraction for Douglas-fir beetles.

79. Dyer, E.D.A.; Safranyik, L. 1977.

Assessment of pheromone-baited trees on a spruce beetle population (Coleoptera: Scolytidae).

Can. Entomol. 109: 77-80.

Density of attack was similar on windfalls and baited trees, but 95% of the overall attack was on windfalls. The authors estimate that 34 baited trees would be needed to replace each windfall in order to to trap 90% of the beetle population.

80. Dyer, E.D.A.; Skovsgaard, J.P.; McMullen, L.H. 1968.

Temperature in relation to development rates of two bark beetles.

Can. For. Serv. Bi-mon. Res. Notes. 24: 15-16.

Spruce beetle and Douglas-fir beetle were reared on host logs at four temperatures. Patterns of development were similar, but spruce beetles develop more rapidly than Douglas-fir beetles at lower temperatures.

81. Dyer, E.D.A.; Taylor, D.W. 1968.

Attractiveness of logs containing female spruce beetles, *Dendroctonus obesus*, (Coleoptera: Scolytidae).

Can. Entomol. 100: 769-776.

The attractiveness of baited and unbaited logs was compared; 89% of the beetles were caught on the logs which contained female spruce beetles. More males were attracted at first, but the sex ratio evened out after the initial flight.

82. Dyer, E.D.A.; Taylor, D.W. 1971.

Spruce beetle brood production in logging slash and windthrown trees in British Columbia.

Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-62. Victoria, B.C. 16 p.

Beetles can breed in slash, but usually more beetles were absorbed than produced. Slash can provide refuge in years where windfall is rare and standing trees are not attacked. Windfall is the primary brood site around cut areas. The authors recommend: 1. Remove windfall from cut boundaries annually. 2. Avoid cut boundaries on ridge-tops or where exposed to severe winds. 3. Avoid Partial and strip-cuts which increase the hazard of beetle build-up.

83. Fiddick, R.L. 1978.

Use of felled trap trees as a supplementary technique for reducing spruce beetle populations.

Can. For. Serv., Pac. For. Res. Cent. BC-P-23. Victoria, B.C. 2 p.

This report describes techniques recommended in British Colmbia. Methods and standards for preliminary survey, deployment of trap trees, characteristics of trap trees, and treatment of trap trees are discussed.

84. Fitzgerald, O.A. 1954.

Beetle proofing the big timber country.

Am. For. 60(1): 24-25, 53-56.

Describes the efforts made to control spruce beetle in Idaho and Montana, where the infested timber is "hot logged."

85. Fletcher, J. 1887.

The spruce bark beetle (*Dendroctonus rufipennis* Kirby).

Appendix to the Report of the Minister of Agriculture. Report of the Entomologist and Botanist p. 34-35. Canada.

The author describes an 1875-86 epidemic near Windsor Mills, Quebec when all the spruce on dry sites were killed but the spruce on wet sites were not attacked.

86. Fowler, G.W.; O'Regan, W.G. 1974.

One-sided truncated sequential t-test: application to natural resource sampling.

U.S. For. Serv. Res. Pap. PSW-100. Pac. Southwest For. and Range Exp. Stn. Berkeley, Calif. 17 p.

The test procedure is described. Brood density sampling of spruce beetle is used as an example.

87. Frye, R.; Flake, H.W.; Germain, C.J. 1974.

Spruce beetle winter mortality resulting from record low temperatures in Arizona.

Environ. Entomol. 3:752-754.

A low temperature of –40°C resulted in an overall mortality of 88% above snow level. Below the snow level, 15% of the larvae and 28% of the adults died. Associated insects suffered a lower mortality.

88. Frye, R.H.; Schmid, J.M.; Lister, C.K.; Buffam, P.E. 1979.

Post-attack injection of Silvisar 510® (cacodylic acid) in spruce beetle (Coleoptera: Scolytidae) infested trees.

Can. Entomol. 109: 1221-1225.

Half-strength formulations can be used if they are applied soon after attack. Arsenic is translocated to needles, but does not leach into the soil within one year.

89. Frye, R.H.; Wygant, N.D. 1971.

Spruce beetle mortality in cacodylic acid-treated Engelmann spruce trap trees.

J. Econ. Entomol. 64: 911-916.

Undiluted Silvisar 510® was injected into axe-cut frills on standing trees. The trees were felled after 9-14 days. Trap trees are lethal to *D. rufipennis* and other bark beetles. Abnormal galleries were constructed in treated trees. Very light blue-stain development was noted. *Trypodendron lineatum* (Oliv.) was not affected.

90. Funk, B. 1950.

Blitz of the beetles.

Reader's Digest 56: 100-102.

(Copy not received)

91. Furniss, M.M.; Baker, B.H.; Hostetler, B.B. 1976.

Aggregation of spruce beetles (Coleoptera) to seudenol and repression of attraction by methylcyclohexenone in Alaska.

Can. Entomol. 108: 1297-1302.

Seudenol plus *alpha*-pinene attracted more spruce beetles than did frontalin, and methylcyclohexenone reduced attractiveness by up to 99%. No *Thanasimus* were caught.

92. Furniss, M.M.; Baker, B.H.; Werner, R.A.; Yarger, L.C. 1979.

Characteristics of spruce beetle (Coleoptera) infestation in felled white spruce in Alaska.

Can. Entomol. 111: 1355-1360.

Methylcyclohexenone did not prevent the infestation of felled trees, and the beetles showed a preference for shaded locations. Polygraphus and other insects prefer top sides.

93. Furniss, R.L.; Carolin, V.M. 1977.

Western forest insects.

U.S. For. Serv. Misc. Publ. 1339. 654 p.

This document gives descriptions of insects and the damage they do, their life cycle, and detection and control techniques.

94. Gara, R.I.; Holsten, E.H. 1975.

Preliminary studies on Arctic bark beetles (Coleoptera: Scolytidae) of the Noatak River drainage.

Z. Angew. Entomol. 78: 248-254.

The authors provide biological observations on eight species, including the spruce beetle. Flight habits, food selection, and behavior in relation to survival are also described.

95. Gardiner, L.M. 1970.

New northern Ontario spruce beetle compels May start on log spraying.

Can. For. Indust. 90: 50-51, 53.

This report is mainly concerned with wood-borers, but includes *Dendroctonus.* Log decks were sprayed with *gamma*-benzenehexachloride emulsion in water to prevent damage (0.4% a.i. applied to run-off).

96. Germain, C.J.; Wygant, N.D. 1967.

A cylindrical cage for rearing bark beetles.

U.S. For. Serv. Res. Note RM-87, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

A screen cage with funnel bottom and trap jar were used for rearing bark beetles.

97. Gibson, K.E. 1984.

Use of trap trees for the reduction of spruce beetle-caused mortality in old-growth Engelmann spruce stands in the Northern Region.

U.S. For. Serv. Pest Manage., North Reg., Missoula, Mont. Rept. 84-10. 11 p.

Felled trees were used as traps to remove beetles in several areas, in conjunction with a harvest of infested and susceptible trees. There was some spillover from trap trees to standing timber, but it was within 200 feet of the trap tree group, and was removed with traps.

98. Gibson, K.E.; Byler, J.W. 1981.

Incorporating insect and disease considerations into the planning process on the Flathead National Forest.

U.S. For. Serv., North Reg., State and Priv. For. Rep. 71-7, 14 p.

Mountain pine beetle, spruce beetle, Douglas-fir beetle, root diseases, dwarf mistletoes, stem decays and white pine blister rust all have the potential to affect management decisions. Potential damage and possible management strategies are discussed in this report.

99. Gobeil, A.R. 1935.

The number of larval instars of *Dendroctonus piceaperda* Hopk. as determined by Dyar's rule.

27th Annu. Rep. Que. Soc. Prot. Plants. pp. 60-65.

Larval instars were found to be four in number based on head capsule measurements and use of Dyar's rule.

100. Gobeil, A.R. 1941.

D. piceaperda Hopk.: A detrimental or beneficial insect?

J. For. 39: 632-640.

Monetary losses may not be the best assessment of damage, as little value can be put on dead material. *Dendroctonus piceaperda* Hopk. acts as a tree predator feeding on surplus populations, thus preventing diseases and competition.

101. Graham, S.A. 1922

Some entomological aspects of the slash disposal problem.

J. For. 20: 437-447.

Large debris should be thoroughly burned and piled over stumps if possible, but burning is not recommended for insect control. The best procedure is to pile slash with the largest pieces on or close to the ground, covered with finer material.

102. Graham, S.A. 1956.

Ecology of forest insects.

Pages 261-280 in *E.A. Steinhaus and Smith, R.F. eds. Ann. Rev. Entomol. 1956. Vol. I. 466 p.*

A general discussion of forest insect ecology.

103. Grant, J.; Cottrell, C.B. 1968.

Spruce beetle in British Columbia.

Can. For. Serv., Pac. For. Res. Cent. For. Pest Leafl. 13. Victoria, B.C. 7 p.

This leaflet gives a brief description of the spruce beetle, chronicles its life history, and discusses losses due to beetle activity. It also discusses detection using bark symptoms and foliage color, applied and natural controls and the prevention of outbreaks.

104. Gray, T.G.; Dyer, E.D.A. 1972.

Flight-muscle degeneration in spruce beetles, *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

J. Entomol. Soc. B.C. 69: 41-43.

Muscles degenerate after flight in both male and female spruce beetles. Also, adults emerging to hibernate have smaller muscles than those emerging in the spring.

105. Grinols, W. 1952.

Beetle infestation threat to Inland Empire forests; tree harvest to be rushed.

Miss. Val. Lumberman 84(11): 6-8. (Bibl. Agr. 17: 7001)

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106. Hall, P.M.; Dyer, E.D.A. 1974.

Larval head-capsule widths of *Dendroctonus rufipennis* (Kirby) (Coleoptera: Scolytidae).

J. Entomol. Soc. B.C. 71: 10-12.

Head-capsule widths have four distinct modes that corresponded to the four instars.

107. Hard, J.S. 1974.

The forest ecosystem of Southeast Alaska. 2. Forest Insects.

U.S. For. Serv. Gen. Tech. Rept. PNW-13, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 32 p.

The spruce beetle is the most important bark beetle in Alaska. This report describes infestations in the 1940s and 1950s.

108. Hard, J.S. 1982.

Stand and tree variables associated with spruce beetle attacks in a Kenai Peninsula infestation: Implications for management.

in Proc. 2nd Alaska Integ. Pest Manage. Conf. Jan. 21-22, 1982. Matanuska-Susitna Comm. Coll.

(Copy not received)

109. Hard, J.S. 1985.

Spruce beetles attack slowly growing spruce.

For. Sci. 31: 839-850.

In 1982, unsuccessfully attacked trees or unattacked trees in 1982 had significantly higher mean recent radial growth. Larger diameters and faster radial growth rates were found in stands with lower stocking.

110. Hard, J.S. 1987.

Vulnerability of white spruce with slowly expanding lower boles on dry, cold sites to early seasonal attack by spruce beetles in south central Alaska.

Can. J. For. Res. 17. p. 428-435.

Attacks peaked annually during the early phase of tree radial growth as the rate of expansion slowed. The first trees attacked, and those most heavily attacked were those which expanded slowest, or not at all. High attack densities concentrated in trees on dry, cold soil.

111. Hard, J.S.; Holsten, E.H. 1985.

Managing white and Lutz spruce stands in south-central Alaska for increased resistance to spruce beetle.

U.S., For. Serv. Gen. Tech. Rep. PNW-188, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 21 p.

Thinning is recommended to maintain vigorous growth, and the hypothesis that beetles take advantage of stressed trees with weak defenses is advanced.

112. Hard, J.S.; Werner, R.A.; Holsten, E.H. 1985.

Susceptibility of white spruce to attack by spruce beetles during the early years of an outbreak in Alaska.

Can. J. For. Res. 13: 678-684.

Percent mortality is directly related to the number of spruce per hectare larger than 24.1 cm diameter and is inversely related to mean cumulative growth over the last 5 years. The relationship is portrayed graphically as a stand hazard model.

113. Harris, J.W.E.; Dawson, A.F.; Brown, R.G. 1978.

Detecting windthrow, potential foci for bark beetle (*Dendroctonus rufipennis*) infestation, by simple aerial photographic techniques.

Can. For. Serv., Bi-Mon. Res. Notes. 34: 29.

Simulated windfalls can be identified at scales of 1:600 to 1:12000.

114. Hawksworth, F.G.; Hinds, T.E. 1959.

Progress report on the rate of deterioration of beetle-killed Engelmann spruce in Colorado.

U.S. For. Serv. Res. Note RM-36, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 6 p.

The original volume of a dead stand will be reduced by about 34% after 15 years due equally to windthrow and rot.

115. Heath, R.H. 1982.

The efficacy of pheromone-baited trap trees for scolytid control in North America.

M.P.M. thesis, Simon Fraser Univ., Burnaby, B.C. 112 p.

A general review of the use of pheromones in North America, including risk rating systems, management, and control recommendations.

116. Hinds, T.E.; Buffam, P.E. 1971.

Blue stain in Engelmann spruce trap trees treated with cacodylic acid.

U.S. For. Serv. Res. Note RM-201, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

Stain penetrated the sapwood of untreated trees after 1 year. Time of treatment had no effect. The best treatment for beetle control is also the best for prevention of blue stain. Incipient decay is present in stained sapwood after 1 year.

117. Hinds, T.E.; Hawksworth, F.G.; Davidson, R.W. 1965.

Beetle-killed Engelmann spruce: Its deterioration in Colorado.

J. For. 63: 536-542.

Forty percent of the original volume of Engelmann spruce was lost after 20 years: one-third to decay in standing trees and two-thirds to windthrow. Windthrow is expected to increase as roots deteriorate.

118. Hodgkinson, R.S. 1985.

Use of trap trees for spruce beetle management in British Columbia.

B.C. Minist. For. Pest Manage. Rept. No. 5. Victoria, B.C. 39 p.

This report includes a description and definition of trap trees, and discusses the use of felled trees treated with arsenicals in axe frills. It also describes deployment, efficacy, timing and the disposal of conventional and lethal trap trees as well as the history of their use in British Columbia

119. Holsten, E.H. 1984.

Factors of susceptibility in spruce beetle attack on white spruce in Alaska.

J. Entomol. Soc. B.C. 81: 39-45.

The author confirms the spruce beetles' preference for the largest trees, and notes that most activity is on the north-facing slopes, possibly due to moisture stress brought about by low soil temperatures. A loss rating guide for presently uninfested stands is included.

120. Holsten, E.H. 1985.

Evaluation of monosodium methane arsenate (MSMA) for lethal trap trees in Alaska.

U.S. For. Serv. State and Priv. For., Tech. Rept. R10-7. Anchorage, Alaska. 20 p.

Glowon® at 80 g/L a.i. showed no repellancy and a 99% reduction in brood.

121. Holsten, E.H.; Werner, R.A. 1984.

Evaluation of methylcyclohexenone (MCH) in preventing or suppressing spruce beetle attacks in Alaska.

U.S. For. Serv. State and Priv. For., Tech. Rept. R10-6. Anchorage, Alaska. 16 p.

A high dosage of liquid or granular methylcyclohexenone reduced spruce beetle attacks by 70%, and progeny by 61%. Release rates and inconsistencies of formulations are also discussed.

122. Holsten, E.H.; Werner, R.A.; Laurent, T.H. 1980.

Insects and diseases of Alaskan forest.

U.S. For. Serv. Alaska Reg. Rep. 75. Anchorage, Alaska. 187 p.

A popular description of bark beetles, the damage they do, the hazards they represent, and techniques for controlling them.

123. Holsten, E.H.; Wolfe, R.L. 1979.

Spruce beetle risk rating system for white spruce on the Kenai peninsula.

U.S. For. Serv. Alaska Reg. Tech. Rept. R 10-1, Anchorage, Alaska. 21 p.

The rating system is based on average diameter, age, stand condition and proportion of spruce in the stand canopy.

124. Hopkins, A.D. 1893.

Destructive scolytids and their imported enemy.

Insect Life 6: 123-129.

The spruce beetle is not specifically named, but damage to spruce forests from "the primary attack of a single species of bark beetle" is discussed, with a view to importing European clerid predators.

125. Hopkins, A.D. 1899.

Insect enemies of forests in the northwest.

U.S. Dept. Agric. Div. Entomol. Bull. 21 (new series). 27 p.

This bulletin notes that spruce beetles were found on spruce in Oregon. The beetles attacked spruce that had been defoliated by other insects, and trees girdled by settlers.

126. Hopkins, A.D. 1901.

Insect enemies of the spruce in the northeast.

U.S. Dept. Agric. Div. Entomol. Bull. 28 (new series). 80 p.

Detailed description of insects and their biology, including predators in the northeastern U.S.

127. Hopkins, A.D. 1903.

Forest-insect explorations in the summer of 1902.

Can. Entomol. 35: 60.

The author mentions that the type specimen of *D. similis* is a synonym of *D. obesus* Mann.

128. Hopkins, A.D. 1905.

The Black Hills Beetle.

U.S. Dept. Agric. Bur. Entomol. Bull. 56 (new series). 24 p.

Black hills beetle galleries in spruce are compared to *D. piceaperda* galleries.

129. Hopkins, A.D. 1906.

Bark beetle depredations of some fifty years ago in the Pikes Peak region of Colorado.

Entomol. Soc. Wash. Proc. 8: 4-5.

Both living and dead trees show evidence of major infestations in the past, and dried resin in gallery scars proves that the trees were alive when attacked.

130. Hopkins, A.D. 1909a.

Contributions toward a monograph of scolytid beetles. I. The genus *Dendroctonus.*

U.S. Bur. Entomol. Tech. Ser. No. 17, Part I. 164 p.

Various species of spruce beetles (now synonymized) are described in detail.

131. Hopkins, A.D. 1909b.

Practical information on the scolytid beetles of North American forests.
I. Bark beetles of the genus *Dendroctonus.*

U.S. Bur. Entomol. Bull. No. 83, Part I. 169 p.

A taxonomic description of the spruce beetle (*D. rufipennis*) and species synonomized since 1909. This bulletin includes a description of damage and control methods.

132. Hopkins, A.D. 1909c.

Insect depredations in North American Forests.

U.S. Bur. Entomol. Bull (new series) No. 58 V: 59-101.

Spruce beetle was controlled in Maine in 1900-1901 by concentrating all logging into infested stands.

133. Hopping, G.R. 1950.

Timber types in relation to insect outbreaks in the Canadian Rocky Mountains.

Ont. Entomol. Soc. 81st Annu. Rep.: 72-75.
(Can. Dept. Agric., Div. Entomol., Sci. Serv., Contrib. 2768)

This report shows that climax 300- to 500-year-old Engelmann spruce stands in the Canadian Rocky Mountains have a very low susceptibility to insect outbreaks. It also claims that there have been no destructive outbreaks in hundreds of years. (The spruce beetle is not named in this article).

134. Hopping, R. 1921.

The control of bark-beetle outbreaks in British Columbia.

Can. Dep. Agric. Entomol. Circ. 15:10.

A general discussion of damage and control of several bark beetle species.

135. Hopping, R. 1928.

The influence of slash on bark-beetle outbreaks.

For. Chron. IV(2) 7 p.

Mainly deals with pine insects, but spruce beetles are mentioned briefly.

136. Hopping, R. 1922.

Coniferous hosts of the *Ipidae* of the Pacific Coast and Rocky Mountain regions.

Can. Entomol. 54: 128-134.

List of hosts and bark beetle fauna.

137. Hunt, J. 1956.

Taxonomy of the genus *Ceratocystis.*

Lloydia 19: 1-58.

Includes types associated with bark beetles.

138. Hutchison, F.T. 1951.

The effects of woodpeckers on the Engelmann spruce beetle, *Dendroctonus engelmanni* Hopk.

M.S. thesis, Colorado State Univ., Fort Collins. 73 p.

Discusses the distributions and seasonal feeding habits of three major species of woodpeckers. Woodpecker feeding reduced the beetle population by 55% in the study area.

139. James, R.L.; Goheen, D.J. 1981.

Conifer mortality associated with root disease and insects in Colorado.

Plant Dis. 65: 506-507.

More than 99% of recently dead or dying trees had root disease, and more than 80% of the diseased trees had bark beetle or wood-borer attack.

140. Jensen, A.D. 1967.

Parasites and predators of the Engelmann spruce beetle.

M.S. thesis, Colorado State Univ., Fort Collins. 76 p.

Larvae of predators and parasites were reared through to adult in order to positively identify them. Keys are provided. Life histories and habits of many of the species studied are described.

141. Keen, F.P. 1952.

Insect enemies of western forests (Rev.)

U.S. Dept. Agric. Misc. Publ. 273. 280 p.

A brief description of major forest insect pests, including life cycle and methods for the control of western *Dendroctonus* species.

142. Keen, F.P.; Craighead, F.C. 1924.

The relation of insects to slash disposal.

U.S. Dept. Agric. Circ. 411. 12 p.

Spruce beetles breeding in slash in the northeastern United States pose little or no problem so slash disposal is not economically justified.

143. Kelly, G.W. 1948.

It can happen here.

Green Thumb 5(9): 14-15. (Bibl. Agr. 13: 12635)

Describes the damage done by spruce beetles following a 1939 blowdown in the Flattops Wilderness Area, and warns of danger to Colorado spruce forests.

144. Kline, L.H.; Schmitz, R.F.; Rudinsky, J.A.; Furniss, M.M. 1974.

Repression of spruce beetle (Coleoptera) attraction by methylcyclohexenone in Idaho.

Can. Entomol. 106: 485-491.

Methlcyclohexenone reduced the attractiveness of female-infested logs by 99%.

145. Knight, F.B. 1957.

The effects of woodpeckers on populations of the Engelmann spruce beetle.

J. Colo. Wyo. Acad. Sci. 4: 47-48.

An average brood reduction of 45 to 98% was observed as the intensity of woodpecker work increased.

146. Knight, F.B. 1958.

The effects of woodpeckers on populations of the Engelmann spruce beetle.

J. Econ. Entomol. 51: 603-607.

An average brood reduction of 45 to 98% was observed as the intensity of woodpecker work increased.

147. Knight, F.B. 1960a.

Measurement of Engelmann spruce beetle populations.

Ecology 41: 249-252.

The number of beetles required for the successful attack of a 20-inch (50.8-cm) diameter spruce tree is 1500; 500 beetles are required for a 10-inch (25.4-cm) tree. There were insufficient numbers of beetles produced in the basal 5 feet of an attacked tree to re-infest a single tree of the same size. The numbers of adult beetles just prior to hibernation fit a negative binomial distribution.

148. Knight, F.B. 1960b.

Sequential sampling of Engelmann spruce beetle infestations in standing trees.

U.S. For. Serv. Res. Note RM-47. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

Infestation trends in standing trees can be determined through sequential sampling of brood densities. Spring survey classifies infestations as treatable or non-treatable (decreasing or increasing); fall survey classifies infestations as decreasing, static or increasing, based upon 25 samples.

149. Knight, F.B. 1961.

Variations in the life history of the Engelmann spruce beetle.

Ann. Entomol. Soc. Am. 54: 209-214.

Climatic variations lead to different lengths of life cycles. Two-year cycles are normal, but 1-year cycles are most common in warm low-elevation areas.

150. Knight, F.B. 1969.

Egg production by the Engelmann spruce beetle, *Dendroctonus obesus*, in relation to status of infestation.

Ann. Entomol. Soc. Am. 62: 448.

Eggs per inch of gallery are greatest in an epidemic population, less in a declining population, and lowest in an endemic population.

151. Knight, F.B.; Heikkenen, H.J. 1980.

Meristematic insects (bark beetles and other phloem borers).

Chap. 17, Pages 331-362 in *Principles of forest entomology. 5th ed. New York, McGraw-Hill. 460 p.*

This report is a brief textbook description of meristematic insects and their biology.

152. Knight, F.B.; McCambridge, W.F.; Wilford, B.H. 1956.

Estimating Engelmann spruce beetle infestations in the central Rocky Mountains.

U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn. Pap. 25. Fort Collins, Colo. 12 p.

A method for a systematic ground cruise using 0.1-acre (0.24-ha) plots gave (1) locations of epidemic areas, (2) estimates of the number of infested trees, and (3) locations of infested trees within the epidemic area.

153. Koplin, J.R. 1967.

Predatory and energetic relations of woodpeckers to the Engelmann spruce beetle.

Ph.D. thesis, Colorado State University, Fort Collins, 187 p.

Predator-prey relationships are examined, as well as the metabolic demands of woodpeckers in different ambient temperatures. Estimates are made of the number of prey required to support birds through the winter. The number of prey consumed is higher than expected.

154. Koplin, J.R. 1969.

The numerical response of woodpeckers to insect prey in a subalpine forest in Colorado.

Condor 71: 436-438.

There was a 50-fold increase in the density of woodpeckers in response to insect prey in spruce and pine killed by fire.

155. Koplin, J.R. 1972.

Measuring predator impact of woodpeckers on spruce beetles.

J. Wildl. Manage. 36: 308-320.

A deterministic model using characteristics of woodpeckers and their food requirements at various temperatures to predict the impact of three species of woodpeckers on endemic, epidemic and pan-epidemic larval populations of spruce beetles. The northern three-toed woodpecker was most effective. The woodpeckers were most effective on epidemic spruce beetle populations, and decreased effectiveness was related to the availability of alternate prey and specific adaptations to utilize them. Decreased effectiveness on pan-epidemics related to territoriality and the limitation on numerical response to prey density.

156. Koplin, J.R.; Baldwin, P.H. 1970.

Woodpecker predation on an endemic population of Engelmann spruce beetles.

Am. Midl. Nat. 83: 510-515.

Deterministic model of woodpecker predation. The impact of predation was greatest on an epidemic beetle population.

157. Kusch, D.S. 1967.

An annotated check list of the common bark beetles found in Alberta with a field key to the genera.

Can. Dept. Fish. For., Can. For. Serv. Inf. Rept. A-X-8. For. Res. Lab., Calgary, Alberta. 12 p.

A field key description of *D. obesus* and other bark beetles.

158. Lawko, C.M.; Dyer, E.D.A. 1974.

Flight ability of spruce beetles emerging after attacking frontalin-baited trees.

Can. For. Serv. Bi-mon. Res. Notes 30: 17.

Eighty-two percent of the re-emerged beetles were unable to fly.

159. Lessard, G.D. 1976.

The occurrence and control of the spruce beetle in the southwestern region.

U.S. For. Serv. Southwest. Reg., State and Private For., For. Insect and Dis. Manage. 76-26. Albuquerque, New Mexico. 13 p.

Describes infestations in the White mountains and other areas of Arizona, New Mexico and their history to 1976. Control operations are also outlined.

160. Lessard, G.; Wilson, E.T. 1977.

Evaluating spruce mortality using aerial infrared 70 mm photography in the White Mountains, Arizona.

U.S. For. Serv. Southwest Reg., State and Private For., For. Insect and Dis. Manage. 77-15. Albuquerque, New Mexico. 18 p.

Evaluations of damage using standard methods. Photo interpretation checked by ground truthing showed excellent agreement ($r \geqslant .89$). The method is clearly feasible.

161. Linton, D.A.; Safranyik, L.; Whitney, H.S.; Spanier, O.J. 1984.

Possible genetic control of colour morphs of spruce beetles.

Can. For. Serv. Res. Notes 4: 52-53.

The color of mature beetles (red or black) is determined genetically and is not a result of aging.

162. Lister, C.K.; Schmid, J.M.; Minnemeyer, C.D.; Frye, R.H. 1976.

Refinement of the lethal trap tree method for spruce beetle control.

J. Econ. Entomol. 69: 415-418.

Half-strength Silvisar 510® attracted more beetles than full strength, with 90% mortality of brood. For best results, the poison should be injected in August and the tree should be felled one month later.

163. Logan, J.A.; Schmid, J.M.; Mehl, M.S. 1980.

A computer program to calculate the susceptibility of spruce-fir stands to spruce beetle outbreaks.

U.S. For. Serv. Res. Note RM-393, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 7 p.

Stage II inventory data were used to rate stands.

164. Love, L.D. 1955.

The effect on streamflow of the killing of spruce and pine by the Engelmann spruce beetle.

Trans. Am. Geophys. Union 36: 113-118.

The flow in the White River, Colorado increased after an infestation killed trees.

165. Lyon, R.L. 1958.

A useful secondary sex character in *Dendroctonus* bark beetle.

Can. Entomol. 90: 582-584.

Describes the stridulation organ on the 7th tergite on male beetles which is not present on females.

166. Lyon, R.L. 1965.

Structure and toxicity of insecticide deposits for control of bark beetles.

U.S. For. Serv. Tech. Bull. No. 1343 59 p.

A literature review to 1965, discussing the use of pesticides for preventive and remedial control. Deposit structure and toxicity are described, along with the effects of fumigation, dose, concentration, solvent, moisture of substrate, and weathering on DDT, dieldrin, dinitrocresol, endrin, hystachlor and lindane.

167. McAtee, W.L. 1915.

Bird enemies of forest insects.

Am. For. 21: 681-691.

Many species of birds feed on bark beetles, destroying 50 to 75% of the brood in many trees.

168. McCambridge, W.F.; Knight, F.B. 1972.

Factors affecting spruce beetles during a small outbreak.

Ecology 53: 830-839.

The authors looked at an epidemic 2 years in duration. Beetle mortality mainly due to competition, desiccation and woodpeckers. The stand composition changed in favor of fir and pine, but the mean tree diameter of the residual stand did not change.

169. McComb, D. 1953.

The use of trap trees for control of the Engelmann spruce beetle, *Dendroctonus engelmannii* Hopkins.

M.S. thesis, Colo. State Univ., Fort Collins. 76 p.

(Copy not received)

170. McComb, D. 1955.

Relationship between trap tree felling dates and subsequent Engelmann spruce beetle attack.

U.S. For. Serv. Res. Note INT-23 (old series), Intermt. For. and Range Exp. Stn., Ogden, Utah. 5 p.

Trap trees must be felled just before flight, although trees felled during mid winter are almost as attractive.

171. McGregor, M.D.; Furniss, M.M.; Oaks, R.D.; Gibson, K.E.; Meyer, H.E. 1984.

Methylcyclohexenone pheromone for preventing Douglas-fir beetle infestation in windthrown trees.

J. For. 82: 613-616.

Spruce beetle attacks were reduced by about 80% on trees treated with the pheromone methylcyclohexenone.

172. Mannerheim, C.G. 1843.

Xylophagi.

Pages 296-298 in *Beitrag zur Käferfauna der Aleutischen Inseln, der Insel Sitka and Neu-Californiens.*

Bull. Soc. Imp. Nat. Moscou 16: 175-314.

Type description of *Hylurgus obesus* Mannerheim, 1843.

173. Massey, C.L. 1953.

Engelmann beetle.

Am. For. 59: 31, 51.

A description of beetles, beetle damage, and symptoms. Natural controls include woodpeckers, parasites, and extreme fluctuations in winter temperatures. Spray of orthodichlorobenzene in diesel should be used on standing trees or an emulsion of ethylene dibromide can be used as a fumigant.

174. Massey, C.L. 1956.

Nematode parasites and associates of the Engel-

mann spruce beetle (*Dendroctonus engelmanni* Hopk.).

Proc. Helminthol. Soc. Wash. 23: 14-24.

Description of four endoparasites and one ectoparasite.

175. Massey, C.L.; Chisholm, R.D.; Wygant, N.D. 1953.

Chemical control of the Engelmann spruce beetle in Colorado.

J. Econ. Entomol. 46: 951-955.

Orthodichlorobenzene in oil or an ethylene dibromide emulsion result in up to 99% mortality of spruce beetles.

176. Massey, C.L.; Wygant, N.D. 1954.

Biology and control of the Engelmann spruce beetle in Colorado.

U.S. Dep. Agric. Circ. 944, 35 p.

The life cycle of and control methods for Engelmann spruce beetle. Lists of associated insects are also included.

177. Massey, C.L.; Wygant, N.D. 1973.

Woodpeckers: most important predators of the spruce beetle.

Colo. Field Ornithol. 16: 4-8.

Woodpeckers accounted for 28% of mortality of low beetle populations, 84% mortality during outbreaks, and 53% at epidemic densities. Broods were reduced up to 98% on heavily worked trees.

178. Mielke, J.L. 1950.

Rate of deterioration of beetle-killed Engelmann spruce.

J. For. 48: 882-888.

Eighty-four percent of the beetle killed trees were still standing after 25 years. The trunks were still sound, although there was occasional basal sapwood decay. The moisture content of standing trees was less than 22% after three years.

179. Miller, M.C.; Moser, J.C.; McGregor, M.; Gregoire J.-C.; Basier, M.; Dahlsten, D.L.; Werner, R.A. 1987.

Potential for biological control of native North American *Dendroctonus* beetles (Coleoptera; Scolytidae)

Ann. Entomol. Soc. Am. 80. p. 417-428.

Spruce beetle is mentioned along with other major North American *Dendroctonus* species as a potential target for biological control using predatory clerid or *Rhizophagus* beetles.

180. Miller, P.C. 1970.

Age distributions of spruce and fir in beetle-killed forests on the White River Plateau, Colorado.

Am. Midl. Nat. 83: 206-212.

A 1940s epidemic killed almost all the spruce and fir larger than 10 cm on the White River Plateau, Colorado. Reconstruction of age classes of trees at the time of attack suggested a previous epidemic in the early 1700s, based on a reduced rate of spruce reproduction later in the same century.

181. Minnemeyer, C.D. 1975.

Dosages of cacodylic acid in Engelmann spruce trap trees, and its effect on the spruce beetle.

M.S. thesis, Colorado State University, Fort Collins, 76 p.

(Copy not received)

182. Mitchell, J.C.; Schmid, J.M. 1973.

Spruce beetle: mortality from solar heat in cull logs of Engelmann spruce.

J. Econ. Entomol. 66: 401-403.

Logs were rotated through 180° to expose the infested lower sides to solar heat. This resulted in up to 90% beetle mortality.

183. Mitchell, M.E.; Love, L.D. 1973.

An evaluation of a study on the effects on streamflow of the killing of spruce and pine by the Engelmann spruce beetle.

Ariz. For. Notes, Northern Ariz. Univ School of For. 1973 No. 9. Flagstaff, Ariz. 20 p. (Abstract only CAB abstracts)

The death of trees resulted in a significant increase in annual stream flow.

184. Mitton, J.B.; Sturgeon, K.B. (eds.) 1982.

Bark beetles in North American conifers

Austin, Univ. of Texas, 527 p.

The authors put forth a system for the study of evolutionary biology, plus an extensive discussion by various authors of all aspects of bark beetle biology. A reference list is included.

185. Moeck, H.A. 1978.

Field test for primary attraction of the spruce beetle.

Can. For. Serv. Bi-mon. Res. Notes 34: 8.

Spruce beetles were attracted to freshly cut bolts of spruce. Attractiveness is low, so sensitive methods are needed to detect beetles as they arrive.

186. Moeck, H.A. 1981.

Ethanol induces attack on trees by spruce beetles *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

Can. Entomol. 113: 939-942.

Ninety-five percent ethanol induced spruce beetles to attack apparently healthy trees.

187. Mogren, E.W. 1958.

Local cord-volume table for beetle-killed Engelmann spruce on the Routt National Forest, Colorado.

Colo. State Univ. Coll. of For. and Range Manage. Res. Note 8. 2 p.

(Copy not received)

188. Morris, O.N.; Olsen, P. 1970.

Insect disease survey in British Columbia, 1965-1969.

Can. Dep. Fish. For., Can. For. Serv. Pac. For. Res. Cent. Inf. Rep. BC-X-47. Victoria, B.C.

Beauveria bassiana and a microsporidian were found on *D. obesus* in 1968.

189. Morris, R.F. 1958.

A review of the important insects affecting the spruce-fir forests in the Maritime provinces.

For. Chron. 34: 159-189.

A history of early outbreaks in eastern Canada, along with epidemiology and control.

190. Mueller, L.A. 1959.

Beetle-killed Engelmann spruce shows promise as a raw material for particle board.

U.S. For. Serv. Res. Note RM-35, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 6 p.

(Copy not received)

191. Murtha, P.A. 1985.

Photo interpretation of Spruce beetle-attacked spruce.

Can. J. Remote Sens. 11: 93-102.

1:4000 and 1:2000 color-infrared photos were used. Crown symptoms for damage types are described. The methods used were found to be highly indicative (93.1% correct) of successful spruce beetle attack.

192. Murtha, P.A.; Cozens, R. 1985.

Color infra-red photo interpretation and ground surveys evaluate spruce beetle attack.

Can. J. Remote Sens. 11: 177-187.

Photos at 1:2000 and 1:16000 were used to locate beetle activity and the results were as valuable to managers as ground probes but at 1/20 the cost.

193. Nagel, R.H. 1953.

Dispersion of radioactive Engelmann spruce beetles to trap logs.

Rocky Mt. Conf. Entomol. Rep. 24: 32-34.

Twelve thousand tagged beetles were released and most of the 675 found were within a 1/4 to 1/3 mi. (400-500 m) radius from the release point. Two beetles were recovered 3/4 mile (1200 m) from the release point, one to the north and one to the east.

194. Nagel, R.H. 1964.

Preventing metal corrosion from emulsifiable ethylene dibromide packaged for bark beetle control.

U.S. For. Serv. Res. Note RM-26, Rocky Mt. For. and Range Exp.Stn., Fort Collins, Colo. 2 p.

Epichlorhydrin should be included in the spray concentrate to prevent the corrosion of metal containers.

195. Nagel, R.H.; McComb, D.; Knight, F.B. 1957.

Trap tree method for controlling the Engelmann spruce beetle in Colorado.

J. For. 55: 894-898.

The authors describe the characteristics of trap trees, and discuss how they are effective supplements to chemical control. One trap absorbs as many beetles as 10 standing trees, and has an effective range of 1/4 to 1/2 mile (400-800 m).

196. Nash, R.W. 1937.

Eastern spruce bark beetle.

Mass. For. Park Assoc., Boston. Tree Pest Leafl. 14, 4 p.

This brief article describes the beetle, its life cycle, and its effect on trees. The recommended controls include: fell and burn, rapid processing of infested material, and the possibility of using systemics (zinc chloride or copper sulphate) by hack and squirt techniques.

197. Nash, R.W. 1952.

Eastern spruce bark beetle (*D. piceaperda*).

Pages 75-77 in *Baldwin, H.I., ed. Important tree pests of the northeast. Soc. Amer. For. New England Sect. N.H. Evans Printing Co., Concord, N.H. 191 p.*

A history of epidemics, the life cycle, symptoms of infestation, and control of the eastern spruce bark beetle.

198. Nelson, A.L. 1950.

Beetles kill 4 billion board feet of Engelmann spruce in Colorado.

J. For. 48: 182-183.

A 1939 epidemic began from scattered blowdown in the White River area, and lodgepole pine was killed in some areas where spruce was eliminated.

199. Nelson, A.L. 1954.

Control and salvage policy: Spruce beetle control in Colorado.

J. For. 52: 503-505.

Immediate control of new outbreaks is urged. Timber can be used for sawlogs until it is too badly checked, after which it may be sold as pulpwood. Large quantities of old dead timber allowed construction of a new pulp mill in the affected area in Colorado.

200. Nielson, R.W., editor. 1986.

Harvesting and processing of beetle-killed timber.

Proc. of Seminar sponsored by Forintek and COFI, N. Interior Lumber Group. May 10, 1985, Prince George, B.C.
Forintek Can. Corp. Spec. Publ. No SP-26. Vancouver, B.C. 53 p.

Ten papers presented at a seminar in May, 1985 at Prince George, British Columbia examine the unique problems involved with harvesting and processing dead timber for plywood, lumber, and pulp.

201. Nijholt, W.W.; McMullen, L.H.; Safranyik, L. 1981.

Pine oil protects living trees from attack by three bark beetle species, *Dendroctonus* spp. (Coleoptera: Scolytidae).

Can. Entomol. 1981. 113: 337-340.

Pine oil protected treated trees, and surrounding trees, from attack.

202. O'Connor, J.P.; Nash, R. 1982.

Further records of insects (Dictyoptera, Lepidoptera, Coleoptera, Diptera) imported into Ireland.

Ir. Nat. J. 20: 393-395.

Living *D. rufipennis* adults were found under the bark on rough green lumber imported from Vancouver, British Columbia in 1980. More living specimens were found in 1981.

203. Olson, H. 1953.

Beetle rout in the Rockies.

Audubon Mag. 55: 30-32.

This popular article describes the woodpeckers' impact on beetle populations in a 1940s epidemic in Colorado. The bird population reached a peak 1 to 2 years behind peak beetle population. The birds took up to 75% of the brood in some areas, and close to 100% in some trees.

204. Ostaff, D.P.; Newell, W.R. 1981.

Spruce mortality in Nova Scotia caused by the spruce beetle, *Dendroctonus rufipennis* Kby.

Can. For. Serv., Marit. For. Res. Cent. Inf. Rep. M-X-0704-769X. Fredericton, N.B. 122 p.

Eighteen percent of merchantable white spruce and 5% of the red spruce stands were infested, comprising 9% of overall volume. Attacks were most common in white spruce with a dbh greater than 22 cm.

205. Ostmark, H.E. 1957.

The life history of *Coeloides dendroctoni* Cush., a braconid parasite of the Engelmann spruce beetle.

J. Colo. Wyo. Acad. Sci. 4:48.

The parasitism of spruce beetle broods ranges between 0 and 40%. The life cycle and habits are also described.

206. Otvos, I.S. 1979.

The effects of insectivorous bird activities in forest ecosystems: an evaluation.

Pages 341-374 in *J.G. Dickson, R.N. Connor, R.R. Fleet, J.A. Jackson and J.C. Kroll, eds. The role of insectivorous birds in forest ecosystems. New York, Academic Press. 381 p.*

The author discusses the direct effect of birds as predators of spruce beetles and other insects.

207. Packard, A.S. 1877.

Report on the Rocky Mountain locust and other insects now injuring or likely to injure field and garden crops in the western states and territories. Insects injuring coniferous trees: *Dendroctonus obesus.*

p. 803 in 9th Annu. Rep. U.S. Geol. Geog. Surv.

A description of the "stout reddish-brown beetle" that attacked pines and spruces (may have been *D. valens*).

208. Patterson, T.J. 1950.

A preliminary report on the bionomics of the Engelmann spruce beetle at Bolean Lake, B.C.

Agric. Can., Can. For. Serv., For. Insect Lab., Vernon, B.C. 13 p.

This report gives a detailed life cycle of the Engelmann spruce beetle, and its habitats in south central British Columbia.

209. Phelps, V.H. 1973.

Sitka Spruce: A literature review with special reference to British Columbia.

Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-83. Victoria, B.C. 39 p.

This report reviews the life history of Sitka spruce and all aspects of silviculture. It includes volume and yield tables, and describes the damage caused by major fungal and insect pests.

210. Prater, L.J. 1951.

Battle of the beetles.

Am. For. 57: 18-21.

A popular article that discusses the spraying of orthodichlorobenzene on infested trees in Colorado.

211. Prebble, M.L. 1953.

Canada review of forest entomology, 1948-1953.

Pages 213-220 in *W.J. Hall, ed. Rep. 6th Comm. Entomol. Conf. London. 344 p.*

The author describes spruce beetles that attacked defoliator-weakened spruce in Ontario, and reports increased populations near Vernon, British Columbia which attacked windthrown and standing trees around logging areas.

212. Rettig, E.C. 1952.

The Engelmann spruce bark beetle.

West. For. Conserv. Assoc. Proc. 43: 50-51

The spruce beetle population from a 1949-1950 blow-down posed a major threat to the forests of western Montana and northern Idaho. The salvage of infested material and a trap tree program were the two methods used. An increase in the woodpecker population was noted, and parasites were found on larvae.

213. Richmond, H.A. 1950.

Spruce bark beetles.

Can. Dep. Agric. Sci. Serv. Div. Entomol. Bimon. Prog. Rept. 6: 3.

The development of a spruce beetle infestation at Bolean Lake, British Columbia is reported and the initiation of life-history studies is described.

214. Richmond, H.A.; Kinghorn, J.M. 1951.

The hemlock looper problem in British Columbia.

For. Chron. 27: 30-34.

Beetles attack Sitka spruces after heavy defoliation by the hemlock looper.

215. Riley, C.G. 1940.

Decay in insect-killed spruce.

Pulp Pap. Mag. Can. 41: 611.

The progress of decay in standing white spruce killed in the Gaspé, between 1930 and 1934 is discussed. Forty percent of the sapwood decay occurs between stump and breast height, and amounts to 5.8% of the merchantable volume.

216. Riley, C.G.; Skolko, A.J. 1942.

Rate of deterioration of sawfly-killed spruce on Gaspé Peninsula.

Pulp and Paper Mag. Can. 43: 521-524.

Spruce beetle infestation on the Gaspé Peninsula killed 46% of the white spruce and 17% of the black spruce during the 1930s.

217. Ronco, F. 1961.

Planting in beetle-killed spruce stands.

U.S. For. Serv. Res. Note RM-60, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 6 p.

Spruce seedlings will survive at an elevation of 10 500 feet if partially shaded.

218. Ronco, F. 1967.

Lessons from artificial regeneration studies in a cutover beetle-killed spruce stand in western Colorado.

U.S. For. Serv. Res. Note RM-90, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 8 p.

A summary of several studies relating to the seeding and planting of Engelmann spruce and lodgepole pine. A dense cover of forbs, grasses and sedges developed after salvage logging.

219. Ross, D.A. 1968.

Wood feeding and bark feeding Coleoptera of felled spruce in interior British Columbia, Canada.

J. Entomol. Soc. B.C. 65: 10-12.

The author gives a list of species reared from *Picea glauca* and *P. engelmannii* in the period 1928-30, and in 1965-67. Emergence dates for many species of beetles are also given.

220. Rumbold, C.T. 1936.

Two blue-staining fungi, including two new species, associated with bark beetles.

J. Agric. Res. 52: 419-437.

The author describes some yeast associated with *D. pseudotsugae* and *D. piceaperda.*

221. Rudinsky, J.A. 1961.

Ecology of Scolytidae.

Annu. Rev. Entomol. 7: 327-348.

A literature review covering all aspects of Scolytid ecology.

222. Rudinsky, J.A.; Michael, R.R. 1973.

Sound production in Scolytidae: Stridulation by female *Dendroctonus* beetles.

J. Insect Physiol. 19: 689-705.

Female beetles produce "chirps" by stridulation. The number of emissions per unit of time increases in the presence of other females.

223. Rudinsky, J.A.; Michael, R.R. 1974.

Sound production in Scolytidae: rivalry behavior of male *Dendroctonus* beetles.

J. Insect Physiol. 20: 1219-1230.

A distinctive rivalry stridulation is evoked from males attracted to a single female. Verbenone is multifunctional according to concentration, and endo-brevicomin has a rivalry function as well as an anti-aggregative one.

224. Rudinsky, J.A.; Sartwell, C. Jr.; Graves, T.M.; Morgan, M.E. 1974.

Granular formulation of methylcyclohexenone: An anti-aggregative pheromone of the Douglas-fir and spruce bark beetles.

Z. Angew. Entomol. 75: 254-263.

Attacks by spruce beetle were reduced by 93.3% for five weeks on wind-thrown Sitka spruce by a slow-release formulation of methylcyclohexenone.

225. Rush, P.A.; Lawrence, R.K.; Baker, B.H. 1977.

Preliminary evaluation of color aerial photography to assess beetle-killed spruce in Alaska.

USDA For. Serv. Alaska Reg., State and Private For., For. Insect and Dis. Manage. 77-2. Juneau, Alaska. 13 p.

Color 70-mm transparencies at 1:8000 scale show sufficient detail. Light overcast reduces shadows in photos. Actual counts and estimates show significant relationship, although r^2 was not high.

226. Safranyik, L. 1971.

Spruce beetle.

Environ. Can., Can. For. Serv., North. For. Res. Cent. For. Rep.1(4)

A brief description of spruce beetle damage, population dynamics and tree losses in the Prairie region to 1970.

227. Safranyik, L. 1978.

Spruce beetle mortality in stumps following an operational broadcast burn.

Can. For. Serv. Bi-mon. Res. Notes. 34: 7-8.

In slash burns where less than 50% of the bark on stumps was scorched, the beetle population was not effectively reduced. The adult population was not significantly reduced below the duff except when the bark was totally charred above the duff level.

228. Safranyik, L. 1985.

Infestation incidence and mortality in white spruce stands by *Dendroctonus rufipennis* Coleoptera Scolytidae in central British Columbia, Canada.

IUFRO (International Union of Forestry Research Organizations) symposium on man-made outbreaks of forest pests and their control. Gottingen, West Germany. Aug. 13-17. 1984. Z. Angew. Entomol. 99: 86-93.

The incidence of infestations was directly related to site quality, age of spruce and proportion of spruce component in stands, and was inversely related to altitude. Models are given to predict spruce mortality and the post-infestation diameter of live spruce.

229. Safranyik, L.; Linton, D.A. 1981.

Field testing diesel oil for protecting spruce logs from spruce beetle infestation.

Can. For. Serv. Res. Notes 1: 11-12.

As opposed to unsprayed logs, logs sprayed to run-off with diesel oil had beetle attack reduced by 61%, and progeny reduced by 96%.

230. Safranyik, L.; Linton, D.A. 1982.

Emergence of *Dendroctonus rufipennis* (Coleoptera: Scolytidae) from buried logs.

Can. Entomol. 114: 539-541.

More than 90% of the beetles emerged from depths of 5 and 10 cm, 14% from 20 cm, and 9% from 40 cm. The burial of logging waste is not recommended unless sufficient depth can be assured.

231. Safranyik, L.; Linton, D.A. 1982.

Mortality of spruce beetle broods in bolts submerged in water.

J. Entomol. Soc. B.C. 79: 8-11.

To achieve total mortality of the brood, six weeks submersion was required. Twenty-two days were required to achieve a 50% mortality, and it was concluded that short-term water storage or transport of infested logs is not enough to bring about reliable control.

232. Safranyik, L.; Linton, D.A. 1982.

Effect of water sprinkling of spruce logs on bark beetle attack.

Can. For. Serv. Res. Notes 2: 8-9.

Sprinkling during the daytime only did not reduce attack by spruce beetles, but did reduce attack by *Ips* species.

233. Safranyik, L.; Linton, D.A. 1983.

Brood production by three spp. of *Dendroctonus* (Coleoptera: Scolytidae) in bolts from host and non-host trees.

J. Entomol. Soc. B.C. 80: 10-13.

Spruce beetles produced mature broods in white spruce and lodgepole pine, but no live larvae were produced in Douglas-fir and subalpine fir.

234. Safranyik, L.; Linton, D.A. 1985.

Influence of competition on size, brood production and sex ratio in spruce beetles *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

J. Entomol. Soc. B.C. 82: 52-56.

Egg gallery length, brood production, brood adult size and sex ratio were significantly and inversely related to gallery spacing.

235. Safranyik, L.; Shrimpton, D.M.; Whitney, H.S. 1983.

The role of host-pest interaction in population dynamics of *Dendroctonus rufipennis* (Kirby) (Coleoptera: Scolytidae).

Can. For. Serv., Pac. For. Cent., Victoria, B.C. 12 p. Reprinted from: *Pages 197-212* in *A.S. Isaev, ed. The role of insect-plant relationships in the population dynamics of forest pests. Proc. of an International IUFRO/MAB Symposium, 24-28 Aug. 1981, Irkutsk, USSR. USSR Acad. of Sciences, 1983.*

Population dynamics of the spruce beetle is reviewed with special emphasis on host-pest interactions. Evidence presented suggests that beetles can recognize induced moisture stress in host trees, and that only a small portion of the population attacks standing trees even when windfall density is low. Based on these and similar observations it appears that increased stand susceptibility must coincide with large beetle numbers for an outbreak to occur.

236. Sahota, T.S.; Farris, S.H. 1980.

Inhibition of flight muscle degeneration of precocene II in the spruce bark beetle, *Dendroctonus rufipennis* (Kirby) (Coleoptera: Scolytidae).

Can. J. Zool. 58: 378-381.

Normal post-flight degeneration of flight muscles was temporarily inhibited by topical application of precocene II.

237. Sahota, T.S.; Ibaraki, A. 1979.

Effect of host tree activity on the rate of yolk protein deposition in *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

Can. Entomol. 111: 1319-1323.

Yolk deposition was inhibited by resin exudation from living host trees. It is recommended that yolk deposition rate be used to test effects of various factors on reproduction, rather than counting oviposition.

238. Sahota, T.S.; Ibaraki, A. 1980.

Prolonged inhibition of brood production in *Dendroctonus rufipennis* (Coleoptera: Scolytidae) by Dimilin.

Can. Entomol. 112: 85-88.

Pre-attack feeding on dimilin by adults in the lab caused complete inhibition of larval eclosion. Spraying of 1% solution on logs before an attack caused a 55% reduction of larvae per gallery, and reduced galleries with successful eclosion by 42%.

239. Sahota, T.S.; Ibaraki, A.; Heywood, F.G.; Farris, S.H.; Van der Wereld, A.M. 1981.

Image enhancement for light microscopy.

Stain Technol. 56: 361-366.

Spruce beetle oocytes are used as subjects for the computer enhancement of low-contrast digital images of histological samples.

240. Sahota, T.S.; Thomson, A.J. 1979.

Temperature induced variation in the rates of reproductive processes in *Dendroctonus rufipennis* (Coleoptera: Scolytidae): a new approach to detecting changes in population quality.

Can. Entomol. 111: 1069-1078.

The length of an egg-free gallery, the numbers of eggs per unit of length and the rate of yolk deposition could be used to discriminate population quality.

241. Schaeffer, Walter H. 1954.

A harvesting technique for beetle-killed Engelmann spruce on the western slope of Colorado.

J. For. 52: 860-862.

A plan to reduce the damage to residual trees while harvesting dead material is described. The technique reduced the loss of live trees from 65% using standard logging practices to 40%, thus leaving more than 800 green trees per acre (2400/ha). Skid trails were planned and marked on the ground. The direction of the fall onto skid trails was marked on the trees and some high stumps were left along the skid trails to protect leave trees from being rubbed.

242. Schmid, J.M. 1970.

Dispersal studies with radioactively tagged spruce beetles.

U.S. For. Serv. Res. Note RM-178, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 3 p.

Iodine-131 was used to tag beetles before release. The beetles attacked the closest tress first, but dispersal continued for seven to eight days after release. There was a 4% recovery, and most beetles were recovered downwind. Nematodes did not affect beetle behavior.

243. Schmid, J.M. 1971.

Beetles in the spruce forest.

Colo. Outdoors 20: 32-35.

A general discussion of the spruce beetle life cycle, damage and mortality directed at the layman.

244. Schmid, J.M. 1972.

Reduced ethylene dibromide concentrations or fuel oil alone kills spruce beetles.

J. Econ. Entomol. 65: 1520-1521.

Ethylene dibromide at 0.05 to 0.25 1b./gal. (0.006 to 0.03 kg/L) of fuel oil gave good control. Oil alone is sufficient if it is applied before the beetles reach the adult stage.

245. Schmid, J.M. 1976.

Temperatures, growth and fall of needles on Engelmann spruce infested by spruce beetles.

U.S. For. Serv. Res. Note RM-331, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

Needle temperature changes, rates of fall and discoloration on infested and non-infested trees were measured and compared as a possible aid in remote sensing. The mean needle temperatures were within 1°C. Crowns did not discolor evenly and new growth 1 year after the attack partially hid discolored needles.

246. Schmid, J.M. 1977.

Guidelines for minimizing spruce beetle populations in logging residuals.

U.S. For. Serv. Res. Pap. RM-185, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 8 p.

Based on observations of stumps, tops and cull logs, general guidelines are given for the minimization of spruce beetle populations.

247. Schmid, J.M. 1981.

Spruce beetles in blowdown (*Dendroctonus rufipennis*).

U.S. For. Serv. Res. Note RM-411, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 5 p.

Attack rates and beetle densities differ among trees, and among different surfaces of trees. These differences are discussed in relation to outbreak potential and evaluation procedures.

248. Schmid, J.M.; Beckwith, R.C. 1975.

The spruce beetle.

U.S. For. Serv. Pest Leafl. 127, 7 p.

The spruce beetle life cycle, distribution and hosts are described. Natural control by woodpeckers and other insects normally keep populations low, but they cannot control outbreaks. Management techniques are suggested.

249. Schmid, J.M.; Frye, R.H. 1976.

Stand ratings for spruce beetles.

U.S. For. Serv. Res. note RM-309, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 4 p.

Stands are rated for outbreak potential based on site characteristics.

250. Schmid, J.M.; Frye, R.H. 1977.

Spruce beetle in the Rockies.

U.S. For. Serv. Gen. Tech. Rep. RM-49, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 38 p.

A summary of literature to 1977 detailing life cycle, taxonomy, behavior, history of outbreaks, detection, evaluation and management.

251. Schmid, J.M.; Hinds, T.E. 1974.

Development of spruce-fir stands following spruce beetle outbreaks.

U.S. For. Serv. Res. Pap. RM-131, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 16 p.

Surveys of logged and unlogged areas revealed changes in stocking, structure and growth rates. Changes of those factors related to the time intervals between spruce beetle outbreaks.

252. Shaw, E.W. 1957.

The bark bug's enemy.

Colo. Outdoors 7: 24-25.

The author discusses how woodpeckers helped control spruce beetles in Colorado by reducing the numbers through feeding activity.

253. Shook, R.S.; Baldwin, P.H. 1970.

Woodpecker predation on bark beetles in Engel-

mann spruce logs as related to stand density.

Can. Entomol. 102: 1345-1354.

Northern three-toed and hairy woodpeckers fed most heavily on logs in semi-open forest where the greatest brood was found. There was a 50% beetle brood reduction over winter, and by the fall there was a 71, 83 and 52% reduction in open, semi-open and dense forest, respectively. Woodpeckers were not found feeding in open meadows.

254. Sluss, R.R. 1955.

A taxonomy of mites found associated with the Engelmann spruce beetle in the Uncompahgre National Forest.

M.S. thesis, Colo. State Univ., Fort Collins, 53 p.

Nine species of mites were extracted: six from frass and three from beetles. Descriptions, key and drawings of each are given.

255. Smith, G.W. 1953.

The biology and control of primary bark beetles (*Dendroctonus*) on the Ashley and Wasatch National Forests.

M.S. thesis. Univ. Utah, Salt Lake City.

(Copy not received)

256. Smith, J.H.G. 1955.

Comments on "A harvesting technique for beetle-killed Engelmann spruce stands on the western slope of Colorado."

J. For. 53: 208-209.
Original article by Schaeffer, W.H., J. For. 52: 860-862. 1954.

The author comments upon the use of gross value figures for forests to justify new harvesting techniques.

257. Stewart, A.J. 1984.

Spruce beetle management.

M.P.M. thesis. Simon Fraser Univ., Burnaby, British Columbia, 120 p.

This thesis gives systems approach to spruce beetle management based on a comprehensive review of available information.

258. Swaine, J.M. 1918a.

Canadian bark beetles.

Dom. Can., Agric. Dept., Entomol. Br. Bull. 14 (Tech. Bull.) 143 p.

A description of Canadian bark beetles, and a comparison to other species. Large slash piles are blamed for the build-up of populations leading to outbreaks.

259. Swaine, J.M. 1918b.

Insect injuries to forests in British Columbia.

Pages 220-237 in *Whitford, H.N. and R.D. Craig. Forests of British Columbia. Can. Comm. Conserv., Committee on Forests, Ottawa. 409 p.*

A description of the spruce beetle and its activity in British Columbia. The author recommends fall slash burning, trap trees, and single tree treatment by fell and burn.

260. Swaine, J.M. 1924.

The destructive spruce bark beetle and its control.

Pulp Pap. Mag. Can. 22: 567-569.

This article gives a description of the spruce bark beetle, including its life-cycle. Charactersitics of infested trees are discussed and control and preventive measures are suggested.

261. Swaine, J.M. 1924.

Control of the destructive spruce bark beetle in eastern Canada.

Dom. Can. Dept. Agric. Handbook 48.

The author discusses the history and control of outbreaks, and gives descriptions of insect associates. Also included are diagrams and photos of insects and damage.

262. Swaine, J.M. 1919.

The biology of Canadian bark beetles — introduction.

Can. Entomol. 61: 145-146.

An introduction to a proposed series of publications on Canadian bark beetles from studies in New Brunswick, Ontario and British Columbia which sets out standard procedures and terminology.

263. Swaine, J.M. 1931.

The eastern spruce bark-beetle.

Can. Dept. Agric. Div. For. Insects. Special Circular.

A description of the insect, the damage it does, its life cycle, and method of attack. The author recommends logging or other forms of direct control on felled trees.

264. Swaine, J.M. 1933.

The relation of insect activities to forest development as exemplified in the forests of eastern North America.

Sci. Agric. 14: 8-31.

A general discussion of forest history in eastern North America. Major insect pests are discussed, and the spruce beetle outbreaks in Gaspé and Quebec are mentioned. The symbiosis of blue-stain and bark beetle is described, along with the predation by woodpeckers on a brood.

265. Swaine, J.M. 1933.

The relation of insect activities to forest development as exemplified in the forests of eastern North America.

For. Chron. Vol. IX: 5-32.

A brief description of insects and insect damage in a general discussion of the topic.

266. Swaine, J.M.; Craighead, F.C. 1924.

Studies on the spruce budworm (*Cacoecia fumiferana* Clem.)
Part 1. A general account of the outbreaks, injury and associated insects.

Dom. Can. Dept. Agric. Bull. 37 (new series) (Tech.), 91 p.

The authors refer to a number of past epidemics of spruce beetles in eastern forests. Spruce beetles were not observed attacking trees killed or injured by budworms.

267. Terrell, T.T. 1954.

Mortality of the Engelmann spruce beetle brood during the winter of 1953-1954.

U.S. For. Serv. Res. Note 10, Intermt. For. and Range Exp. Stn., Ogden, Utah. 9 p.

High mortality occurred during the winter when temperatures of –49° to –56° F were recorded.

268. Thomas, J.B. 1954.

Mortality of white spruce, Lake Nipigon area.

Can. Dept. Agric. Sci. Serv. Div. For. Biol. Bi-mon. Prog. Rept. 10. p. 2.

Follows the progress of beetle infestations first reported in 1951, after budworm defoliation. Observations show that colour change of attacked trees is dependent upon local conditions. Red-tops were prevalent in 1951, were rare in 1952, and were absent in 1953. Red needles tend to fall sooner than those which stay green on dead trees, which usually persist to spring of the year after initial attack.

269. Thomas, J.B. 1957.

The use of larval anatomy in the study of bark beetles (Coleoptera: Scolytidae).

Can. Entomol. Suppl. 5, accompanies Vol. LXXXIX, 45 p.

Contains a detailed description of larval anatomy, and a key to the larvae of *Dendroctonus.*

270. Thomas, J.B. 1965.

The immature stages of Scolytidae: the genus *Dendroctonus* Erichson.

Can. Entomol. 97: 374-400.

The external anatomy of several species of *Dendroctonus* larvae is described. Larval and pupal characters support the proposed synonymy by Wood (1963).

271. Thomson, A.J.; Sahota, T.S. 1981.

Competition and population quality in *Dendroctonus rufipennis* (Coleoptera: Scolytidae).

Can. Entomol. 113: 177-183.

Crowding resulted in a decrease of gallery production and oviposition, but increase in individual beetle quality increased the powers of resistance to the effects of competition. Reproductive efficiency was estimated by measuring the rate of yolk deposition.

272. Thomson, M.G. 1951.

Engelmann spruce beetle.

Can. Dept. Agric. Sci. Serv. Bi-mon. Prog. Rept. 7: 4.

The author describes the origin of an infestation at Bolean Lake, British Columbia from 1944-48. The population in a scattered blowdown moved to fresh slash, then into heavy blowdown in shelterwood logging, and from there into surrounding timber.

273. Thomson, M.G. 1955.

Sexing and reclaiming dried specimens of *Dendroctonus engelmannii* Hopk.

Proc. Entomol. Soc. B.C. 51: 45.

A method for sexing spruce beetles by feel using the presence of tubercles on the elytral declivity of females is described. Dried specimens may be reclaimed for histological purposes by soaking them in a 0.5% solution of tri-sodium phosphate for two hours.

274. Thomson, M.G.; Walters, J. 1951.

Engelmann spruce bark-beetle.

Can. Dept. Agr. Sci. Serv., For. Biol. Div., Bi-mon. Prog. Rept. 7: 3.

The relationship between dbh and a lethal attack by spruce beetles is discussed.

275. Thong, C.H.S.; Webster, J.M. 1983.

Nematode parasites and associates of *Dendroctonus* spp. and *Trypodendron lineatum* (Coleoptera: Scolytidae), with a description of *Bursaphelenchus varicauda*, new species.

J. Nematol. 15: 312-318.

Nematode parasites in the gut and hemocoel of the spruce beetle include *Parasitorhabitis obtusa* and *Contortylenchus reversus.*

276. Vaux, Henry J. 1954.

Some implications of the spruce beetle control and salvage programs in Colorado.

J. For. 52: 506-510.

The economics of control and timber salvage are discussed.

277. Vité, J.P.; Pitman, G.B.; Fentiman, A.F. Jr.; Kinzer, G.W. 1972.

3-methyl-2-cyclohexen-1-ol isolated from *Dendroctonus.*

Naturwissenschaften. 59: 469-470.

Methylcyclohexenol was isolated from *Dendroctonus pseudotsugae* female hindguts. This compound is also produced by *D. rufipennis.*

278. Waite, R.S. 1962.

The geographical distribution and control of the destructive bark beetles and defoliating insects in the coniferous forests of Utah.

M.S. thesis. Univ. Utah. Salt Lake City.

(Copy not received)

279. Watson, E.B. 1928.

The bionomics of the spruce bark beetle *Dendroctonus piceaperda* Hopk. The result of observations carried out in the Algoma District of Ontario.

Sci. Agr. 8: 613-635.

A thorough description of the life cycle, hosts, behavior, predation, and associates of the spruce bark beetle. The effect of overcrowding on larvae is discussed, and estimates of brood production per tree and per gallery are given.

280. Wear, J.F.; Pope, R.B.; Orr, P.W. 1966.

Aerial photographic techniques for estimating damage by insects in western forests.

U.S. For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 79 p.

Aerial photography is not recommended for surveys of Engelmann spruce mortality.

281. Werner, R.A. 1978.

The spruce beetle in Alaska forests.

U.S. For. Serv., Pac. Northwest For. and Range Expt. Stn. Portland, Oregon, 2 p.

The author describes the spruce beetle life cycle and gives guidelines for reducing infestation.

282. Werner, R.A.; Averill, R.F.; Hastings, F.L.; Hilgert, J.W.; Brady, J.W. 1984.

Field evaluation of fenitrothion, permethrin and chlorpyrifos for protecting white spruce trees from spruce beetle (Coleoptera: Scolytidae) attack in Alaska.

J. Econ. Entomol. 77: 995-998.

All three pesticides proved adequate for four months. At 16 months, 0.25% permethrin and 2% fenitrothion were still effective. Residue movement to stream and soil was minimal.

283. Werner, R.A.; Baker, B.H.; Rush, P.A. 1977.

The spruce beetle in white spruce forests of Alaska.

U.S. For. Serv. Gen. Tech. Rep. PNW-61. Pac. Northwest For. Range Exp. Stn., Portland, Oreg. 13 p.

The life history of the spruce beetle is given, along with a description of the damage it does to white spruce. The management practices used to prevent outbreaks are also discussed.

284. Werner, R.A.; Elert, E.E.; Holsten, E.H. 1983.

Evaluation of beetle-killed white spruce for pulp and paper.

Can. J. For. Res. 13: 246-250.

There was no difference in pulp yield between trees dead for 1 year, and those dead as long as 50 years. Trees that had been dead for 50 years produced high quality pulp.

285. Werner, R.A.; Hastings, F.L.; Averill, R. 1983.

Laboratory and field evaluation of insecticides against the spruce beetle (Coleoptera: Scolytidae) and parasites and predators in Alaska.

J. Econ. Entomol. 76: 1144-1147.

Of the nine insecticides tested, fenitrothion (2% a.i.) provided the best remedial control, but also killed parasites and predators. Two percent permethrin was almost as effective, but had the least effect on predators and parasites.

286. Werner, R.A.; Hastings, F.L.; Holsten, E.H.; Jones, A.S. 1986.

Carbaryl and lindane protect white spruce *Picea glauca* from attack by spruce beetles *Dendroctonus rufipennis* (Coleoptera: Scolytidae) for three growing seasons.

J. Econ. Entomol. 79: 1121-1124.

One and two percent carbaryl and 0.5% lindane were 100% effective after 16 months. After 3 years, 1% carbaryl was 89% effective, 2% carbaryl was 96% effective, and 0.5% lindane was 94% effective.

287. Werner, R.A.; Holsten, E.H. 1983.

Mortality of white spruce during a spruce beetle outbreak on the Kenai Peninsula in Alaska.

Can. J. For. Res. 13: 96-101.

Twenty-nine percent of all white spruce killed between 1976 and 1980 accounted for 59% of the commercial volume. The impact on structure and species composition is given as well as a discussion of management implications.

288. Werner, R.A.; Holsten, E.H. 1984.

Scolytidae associated with felled white spruce in Alaska.

Can. Entomol. 116: 465-471.

Pheromone traps and trap trees captured 29 scolytid species. All parts of the trees were attacked, with *Ips* species among the most common scolytid species. Geographical differences in distribution were noted.

289. Werner, R.A.; Holsten, E.H. 1985(a).

Factors influencing generation times of spruce beetles in Alaska.

Can. J. For. Res. 15: 438-443.

Direct solar radiation is the primary factor. Two-year generations, usually on the north and west sides of standing trees or on the north and bottom sides of felled trees, convert to one-year cycles if rotated into the sun.

290. Werner, R.A.; Holsten, E.J. 1985(b).

Effect of phloem temperature on development of spruce beetles in Alaska.

Pages 155-163 in *L. Safranyik, ed. Proc. of the IUFRO conference on the role of the host in the population dynamics of forest insects. Joint meeting of IUFRO working parties S2-07-05 and S2-07-06, Banff Centre, Sept. 4-7, 1983. Joint publ. Can. For. Serv., USDA For. Serv., Pacific Forest Research Centre, Victoria, B.C. 240 p.*

A threshold temperature of 6.7°C was required for larval development of 2-year cycle beetles to a further instar by the end of the first summer. A threshold temperature of 16.5°C was required for 1-year cycle beetles to develop.

291. Westergaard, B. 1983.

Northwood confronts beetle.

Logging and Sawmilling J. 14: 16-18.

A history of outbreaks in the Prince George region of British Columbia is given, as well as company efforts toward salvage and control.

292. Whitmore, M.C. 1983.

The interaction of bark beetle (Coleoptera: Scolytidae) populations with their arthropod predators and parasites in felled Alaskan white spruce.

M.S. Thesis. University of Washington. 101 p.

The author identified key arthropods associated with scolytids in white spruce, investigated the impact of predators and parasites, and delineated the host selection behavior of the important scolytids and their predators and parasites.

293. Whitney, H.S. 1982.

Relationships between bark beetles and symbiotic organisms.

Pages 183-211 in *J.B. Mitton and K.B. Sturgeon, eds. Bark beetles in North American conifers. Austin, Univ. of Texas, 527 p.*

The relationships between beetles and associated yeasts, fungi, bacteria and protozoa are described. A list of beetle species and known associates is included.

294. Whitney, H.S.; Funk, A. 1977.

Pezizella chapmanii n. sp., a discomycete associated with bark beetle galleries in western conifers.

Can. J. Bot. 55: 888-891.

P. chapmanii is found in galleries of the major bark beetles in several different host tree species.

295. Wickerham, L.J. 1960.

Hansenula holstii, a new yeast important in the early evolution of the heterothallic species of its genus.

Mycologia 52: 171-183.

Yeast was isolated from bark beetle gallery frass on spruce logs from Quebec.

296. Wilford, B.H. 1960.

Forest-insect surveys in the central Rocky Mountains.

J. Econ. Entomol. 53: 458-462.

Describes and discusses methods used in bark beetle and other surveys.

297. Wilson, A.K. 1958.

Log production in Idaho and Montana, 1956.

U.S. For. Serv. Res. Note 54, Intermt. For. and Range Exp. Stn. Ogden, Utah 7 p.

Report on salvage of beetle-killed spruce in Montana since 1952.

298. Wilson, L.F. 1977.

A guide to insect injury of conifers in the Lake States.

U.S. For. Serv. Agric. Handbook 501. 518p.

A brief description of insects, insect damage and signs of infestation.

299. Wong, H.R.; Melvin, J.C.E. 1973.

Insects associated with trees damaged by hydrocarbon condensate in the Strachan area, Alberta, Canada.

Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X 74. Edmonton, Alta. 19 p.

Spruce beetles were found in the phloem of dead and injured trees.

300. Wood, S.L. 1949.

The Scolytidae of the Logan Canyon area in Utah and their host plants.

Utah Acad. Sci. Arts Lett. Proc. 26: 127-128.

Fourteen species of scolytids have been found on Engelmann spruce.

301. Wood, S.L. 1963.

A revision of bark beetle genus *Dendroctonus* Erichson (Coleoptera: Scolytidae).

Great Basin Nat. 23: 1-117.

A detailed taxonomy of *Dendroctonus* Erichson, including extensive lists of publications to 1958.

302. Wood, S.L. 1969.

New synonymy and records of Platypodidae and Scolytidae (Coleoptera).

Great Basin Nat. 29: 113-128.

A reexamination of old material in North American collections. The synonomy of *D. obesus* and *D. rufipennis* is established: the species is correctly called *rufipennis* by seniority.

303. Wood, S.L. 1977.

Manipulation of forest insect pests.

Pages 369-384 in *H.H. Shorey and J.J. McKelvey Jr., eds. Environmental science and technology. Chemical control of insect behavior. Theory and application. Conference. Bellagio, Italy. May, 1975. VIII + 414 p. Illus. New York, Wiley.*

(Copy not received).

304. Wood, S.L. 1982.

The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph.

Great Basin Nat. Mem. No. 6. 1359 p.

A detailed taxonomy of bark and ambrosia beetles, including descriptions of habits and distribution.

305. Wright, R.H.; Chapman, J.A.; Dyer, E.D.A. 1974.

Molecular vibration and insect attraction.

Can. For. Serv., Bi-mon. Res. Notes. 30: 10-11.

Four compounds which were spectrally similar to but chemically different from frontalin were field tested for attractiveness to spruce beetle. One compound was comparable under the test conditions, and the other three showed some activity.

306. Wygant, N.D. 1956.

Engelmann spruce beetle control in Colorado.

Proc. Tenth Int. Congr. Entomol. 4: 181-184.

A brief description of the life history and habits of the spruce beetle, plus a history of previous outbreaks and the amount of chemical and silvical controls applied. Recommendations are given for the reduction of losses and the prevention of epidemics.

307. Wygant, N.D. 1959.

Bark beetle control.

J. For. 57: 274-277.

A review and appraisal of bark beetle problems, control, and research needs.

308. Wygant, N.D. 1959.

Status of insect control on private forest lands in the southwest.

Pages 21-24 in *Time for action in the woods. Timberland Owners Conf. Proc., Southwest Region, Santa Fe, New Nexico, Sept., 1958.*

A summary of problems, damage, and cooperative efforts to reduce losses.

309. Wygant, N.D.; Lejeune, R.R. 1967.

Engelmann spruce beetle *Dendroctonus obesus* (Mann) (= *D.engelmanni* Hopk.).

Pages 93-95 in *Important forest insects and diseases of mutual concern to Canada, the United States and Mexico. Can. Dep. For. and Rural Dev., Publ. No. 1180, Ottawa. 248 p.*

Describes the geographic distribution, damage, life history, impact, and control measures for the Engelmann spruce beetle, and defines the need for further research with reference to control.

310. Yeager, L.E. 1955.

Two woodpecker populations in relation to environmental change.

Condor 57: 148-153.

There was a build-up of woodpeckers during and after the peak of a spruce beetle epidemic. It is not known if peak woodpecker populations were due

to reproduction or to concentration. The population peaked at around 900/mi^2 (350/km^2).

311. Yeager, L.E.; Riordan, L.E. 1953.

Effects of beetle-killed timber on range and wildlife in Colorado.

Pages 596-616 in *Trans. 18th North. Am. Wildl. Conf.*

Describes the changes in range and forest cover after the forest was killed by spruce beetle. The effect on summer range for deer, elk and livestock is also discussed.

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