



forestry report

CAN

MENT CANADA
TRY SERVICE

ENVIRONNEMENT CANADA
NORTHERN FOREST RESEARCH CENTRE

NOVEMBER, 1974

EDMONTON, ALBERTA

VOL. 4 NO. 1

POPLARS in the Prairie Provinces

The story of poplars is an unusual tale – a rags to riches story. The poplar has gone from weed to valuable resource, because today this abundant species is being regarded by many as a possible source of newsprint, tissue, plywood and even livestock feed. Poplars provide choice winter and summer food for white-tailed deer and grouse, and the first prairie homes were built with and heated by poplar logs. Often considered a weed, the poplars of the Prairies are now facing a brighter future.

Poplars are fast-growing, short-lived trees supported by shallow, wide-spreading root systems. Aspen in particular propagates chiefly by means of suckers that arise from roots near the surface of the ground, a characteristic that is of great importance in the natural re-generation of poplar on cutover and burned-over areas. Other species sprout readily from stumps or shoots. This vegetative reproduction results in the development of large numbers of individuals of identical characteristics (clones) that may spread over 3 to 4 acres.

Besides being used by the wood-fibre industries, poplars are a familiar ornamental tree, and farm sites are made more attractive and protected from the sharp prairie winds by poplar shelterbelts.

This issue of FORESTRY REPORT is being devoted entirely to the familiar POPLARS of the prairie region, for if ever there was a tree that could boast of being a "true champion" of multiple use, it is the versatile poplar. In addition to serving a wide variety of man's needs, it provides home and food for wildlife, heals quickly our scarred landscape, and provides a brilliant splash of fall color to dazzle the eye.



Poplar Plantings on the Prairies

Tree planting on the plains of Canada was initiated by the then Forestry Branch, Canada Department of Interior, in 1901 for farm shelterbelts and uses other than forestry. A federal tree nursery was established at Indian Head in 1903 to produce and supply the deciduous and coniferous tree material for such plantings in the prairie region. A second federal nursery was established at Sutherland in 1913 to service the Northern areas of the prairies, but it was closed in 1966 to consolidate all operations at Indian Head.

Since 1909 the Indian Head and Sutherland nurseries in Saskatchewan have provided poplar material for 33,000 miles of plantings in the prairie region. Most of this material was utilized for farm shelterbelts (initially primarily in chinook areas), although 10% has been used in parks, conservation and urban developments. Annual demands for poplar gradually increased from 200,000 (Fig. 1) to over one million cuttings. However, demands declined from 1.3 million cuttings in 1929 to a low of about 100,000 cuttings in 1938 following planting failures due to periodic drought, disease and insect infestations. These adverse conditions decimated numerous poplar shelterbelts and nursery cutting beds. From the early 1940's until 1965 production and planting demands averaged about 250,000 plants. Production of superior clones and rooted cut-

tings increased planting demands in 1966 and 1967 to a high of 750,000 plants. Since 1969 with the development of mechanization and storage techniques only rooted cuttings have been produced to improve survival and development of prairie plantings. As a result demands continued to exceed production which has increased from 150,000 (1971) to 500,000 plants annually (1974). Nursery production problems have reduced available poplar material below the planting demand and production objective of one million rooted cuttings annually.

Research by nursery staff since 1948 has provided superior clones and equipment, propagation and storage techniques, controls for insects and diseases, and herbicidal and irrigation practices for expanding nursery production. Wider spacing for plantings were introduced in 1971 to improve survival of poplar in shelterbelts under climatic stresses.

Poplar material has also been provided for plantings in Alberta by the provincial nursery at Oliver since 1950. This material is utilized primarily for farm shelterbelts, and parks. From 1969 to 1973 material for 150 miles of plantings were planted in Alberta.

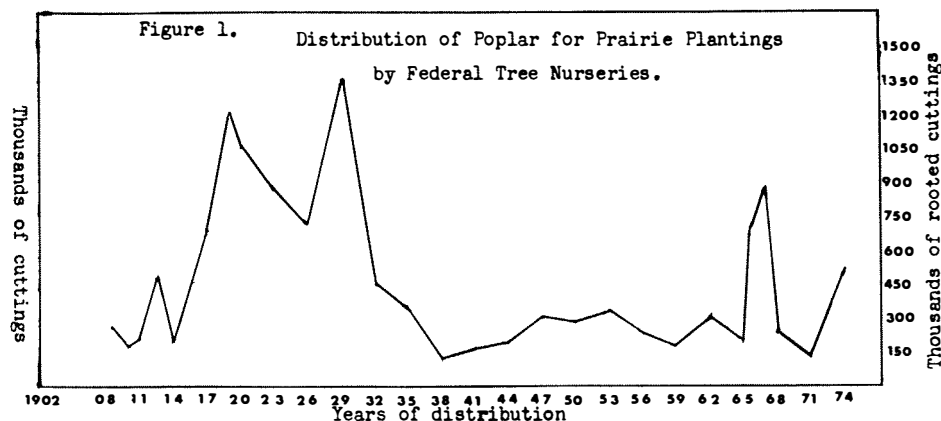
Some 200 clones, species and hybrids were collected or produced, and evaluations for performances (1, 2) initiated from 1948 to 1951.

Plantings to evaluate some 106

poplar clones for the prairie region were established in Manitoba, Saskatchewan and Alberta from 1965 to 1974. Although several of these plantings were initiated as co-operative studies with provincial and federal agencies, 21 were carried out by nursery staff (Fig. 2). Briefly these plantings have identified the most promising clones (Walker, Northwest, Saskatchewan, berolinensis, gelrica, tristis and cardenensis). Severe winter injury in 1972-73 and 1973-74 of new poplar plantings, suggest that three clones were frost hardy.



Fig. 2. Poplar regional test plantings of clones (1) Northwest, (2) gelrica, (3) Brooks, (4) Walker, (5) berolinensis



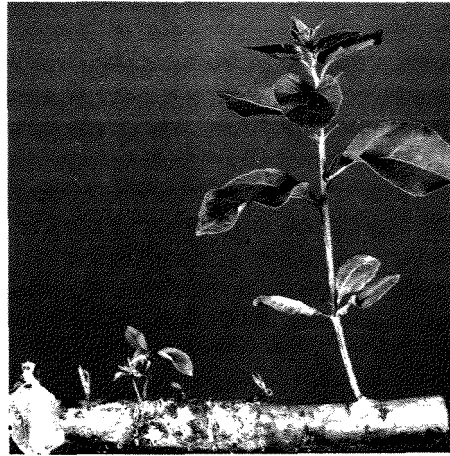
REFERENCES

1. Cram, W. H. 1954. *Trees Breeding-Poplar. Dominion Forest Nursery Stations, Progress Report 1947 - 1952.* page 35.
2. Cram, W. H. 1960. *Performance of seventeen poplar clones in south central Saskatchewan. For. Chron. 36: 204-209.*
3. Cram, W. H. 1969. *Poplars for grassland plantings. Chap. VI. pp. 113-115. Growth and Utilization of Poplars in Canada, For. Branch. Dept. Pub. No. 1025.*
4. *Summary Reports, 1958 to 1962, Forest Nursery Station, Indian Head Sask., Canada Agriculture, (mimeo).*
5. *Summary Reports, 1963 to 1973, Tree Nursery, Indian Head, Sask., P.F.R.A., Canada Agriculture (mimeo)*
6. *Summary Reports, 1969 to 1973, Tree Nursery, Indian Head, Sask., P.F.R.A., Regional Economic Expansion Canada.*

The Familiar Poplar

Native poplar species in Canada are present in all parts of Alberta, Saskatchewan and Manitoba. Trembling aspen (*Populus tremuloides* Michx) and balsam poplar (*P. balsamifera* L.) are the most common poplars and occur throughout all three provinces. Although less common, the plains cottonwood (*P. deltoides* var. *occidentalis* Rydb.) grows throughout the Prairies. Large-tooth aspen (*P. grandidentata* Michx) is limited to eastern Manitoba, whereas black cottonwood (*P. trichocarpa* Torr. and Gray) and narrowleaf cottonwood (*P. angustifolia* James) occur only in southwestern Alberta and southern Alberta and Saskatchewan respectively.

The poplars are intolerant pioneer species and will colonize a variety of habitats. The cottonwoods and balsam poplar prefer wet habitats including riverbanks and freshly exposed sandbars. The aspens will invade burns and cutovers on upland well-drained sites. The wetter



Sucker on aspen root

depressions on these sites will tend to be occupied by balsam poplar.

Generally all the poplars are dioecious, i.e., male and female flowers occur on separate trees.

Flowering usually starts at age 10 to 15. Regeneration by seed is more common with the cottonwoods and balsam poplar than the aspens, partly because of habitat characteristics.

Vegetative reproduction through root suckers is common with all the poplars. Stem cuttings of the cottonwoods and balsam poplars root readily. Rooting of aspen stem cuttings is almost nil. Some regeneration occurs through stump and root-collar sprouts, particularly with the cottonwoods and balsam poplar.

Of all the poplars on the Prairies the plains- and black Cottonwood probably grow to the largest size. They can reach a height of 100' or more and a stem diameter of several feet. Trembling aspen and balsam poplar are the most important species for the wood-using industry. The cottonwoods and their hybrids play an important role in the agricultural zone, where they are used for farm and amenity planting. ...

Wood Properties of Poplar

A number of economic reasons have been cited for the low level of utilization of the poplar resource. The central economic factor has been the ready availability of preferred softwood species which could be processed into the traditional wood products (lumber, pulp and plywood) at lower cost and with higher returns, than was possible with the poplars. A combination of two characteristics of the poplar resource: (1) the high proportion of relatively crooked, small diameter trees in natural stands and (2) the relatively high incidence of decay in mature stands, have largely contributed to the higher costs of processing poplars. However, with increas-

ing demands for wood and fibre products and dwindling supplies of preferred species, a greater utilization of the poplar resource can be expected. Have the poplar species and principally trembling aspen the desired characteristics that will favor such increased utilization?

Because of the two above mentioned characteristics of the poplar resource, probably the greatest increase in utilization can be expected in fibre products such as pulp and paper, fibreboard and particleboard.

In pulping, poplar could be used either pure or in mixture with other species. Poplar kraft pulp is quite well suited for fine paper be-

cause of excellent sheet formation, high opacity, good bulk and good printability. Except for strength, it compares favorably with kraft pulps from softwoods (Table 1). The short fibre length of about 1.0 mm for poplar compared to 3.5-4.0 mm in most softwoods, and the lower proportion of tracheids in poplar are responsible for this lower strength. On the other hand, the high cellulose content, low lignin content, and ease of penetration by alkaline pulping liquors of poplars results in higher yields, lower alkali consumption, and faster pulping rates than for spruce at the same pulp lignin content.

Cont'd. Page 8

ENEMIES

A wide variety of insects and mites feed on poplars. The Forest Insect and Disease Survey of the Canadian Forestry Service has records of at least 300 species of insects on living trembling aspen alone. Here we deal with some of the more important species attacking the catkins, leaves, branches, trunk, roots and causing the formation of galls on poplars especially trembling aspen.

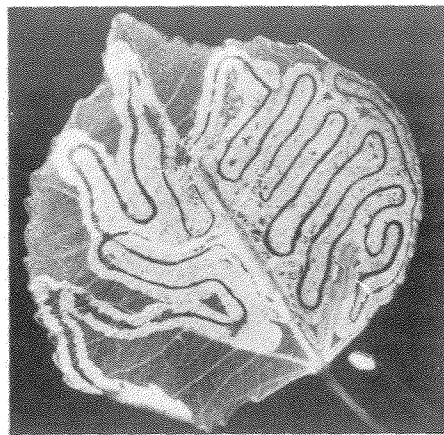
The most common species damaging catkins are a micro moth, *Epinotia nisella* Clerk; a dagger



Malacosoma disstria

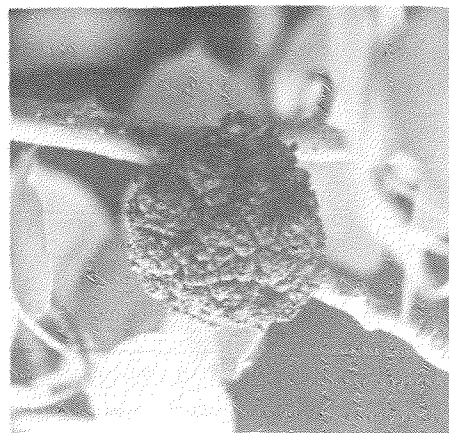
moth, *Anathix puta* (G. & R.) and weevils, *Dorytomus* spp. The larvae of the moths feed on buds or capsules of catkins and then on the developing leaves. The weevil bore into and consume the interior of the bud, stalk and main stem of catkins.

The largest group of insects feed on the leaves. Outbreaks of the forest tent caterpillar, *Malacosoma disstria* (Hbn.) and the large aspen tortrix, *Choristoneura conflictana* (Wlk.) have caused almost complete defoliation of trembling aspen in vast areas of the three Prairie Provinces for a number of years. The Bruce spanworm, *Operophtera bruceata* (Hulst) and the aspen twin-leaf tier, *Enargia decolor* Wlk. have severely stripped the leaves of aspen in parts of Alberta. A leaf roller, *Pseudexentera oregonana* (Wlshn.) has caused serious damage to the



Phyllocnistis populiella

developing leaves. Unlike moths, which feed only on the foliage in the larval stage, the beetles consume the leaves in the larval and adult stages. Extensive damage has been caused by the aspen leaf beetle, *Chrysomela crotchii* Brown, the American aspen beetle, *Gonioctena americana* (Schaeff.) and the gray willow-leaf beetle, *Pyrralta decora decora* (Say). Larvae of moths and beetles have also caused serious damage by feeding inside the leaf. The aspen leaf miner, *Phyllocnistis populiella* (Chambers) makes meandering mines in the upper and lower epidermis; the aspen blotch miner, *Lithocolletis salicifoliella* Chambers produces irregularly shaped blotches

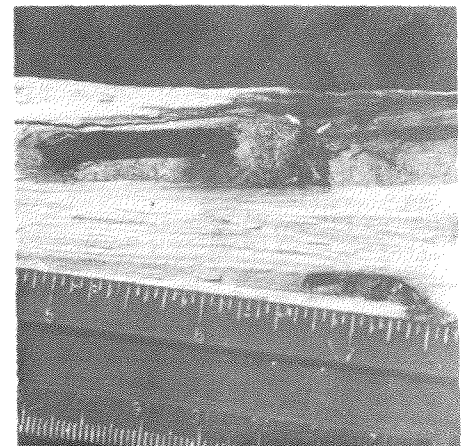


Aceria parapopulion

by feeding on the mesophyll of the leaves; and the cottonwood leaf-mining beetle, *Zeugophora scutellaris* Suffr. attacks some of the hybrid

poplars used as shelterbelts by mining the leaves in the larval stage and skeletonizing the leaves in the adult stage.

The most serious wood borer of aspen is the poplar borer, *Saperda calcarata* Say. Larvae of this beetle mine initially beneath the bark and then into the sapwood and heartwood. In small trees growing on poor sites, the poplar borer mine into the root and root collar. Damage by this insect degrades lumber and veneer and the tunnels serves as infection court for wood rotting fungi. The twigs and smaller branches are attacked by the twig borer, *Oberea schaumii* Lec. Trees weakened by natural factors such as defoliation, mechanical damage, wind



Saperda calcarata damage

breakage, etc. predisposes them to attacks by the bronze poplar borer, *Agrilus liragus* B. & B. and the ambrosia beetle, *Trypodendron retusum* (Lec.). The former produces zigzag galleries in the stem and branches and the latter bore into the woody tissues and feed on the ambrosia fungus, which stain the walls of their galleries.

Some of the insects and mites stimulate aspens to produce unsightly galls, which may persist on the trees for several years. The more common galls are caused by the poplar vagabond aphid, *Mordwilkoja*

of POPLAR

vagabunda (Walsh) feeding on the leaf stipules; the poplar bud-gall mite, *Aceria parapopuli* (Keifer), attacking the new buds and newly unfolding leaves; and the poplar gall sawfly, *Saperda inornata* Say tunnelling into twigs and small branches.

DEFECTS IN POPLAR:

Defects in poplar are receiving greater attention from natural resource managers, forest products users, nursery managers and urban and rural land owners as poplars are put to greater use. Defects may be caused by occasional epidemics of biological agents, but a more important and persistent cause is weather.

FROST INJURY

Night frost alternating with warm days during spring, fall and winter months causes a freeze-thaw condition that damages living tissues in the bark, leaf and sapwood of the tree. All species and hybrids are affected. Land form, night inversion temperature, alternate layers of cold and warm air, sudden invasion of cold or warm gusty winds, clearings, age and stand density influence the risk of frost damage. Defects in poplars caused by frost in-



Frost cankers and dieback in Russian Poplar showing damage and subsequent wind-breakage.

clude girdling causing cankers and diebacks and growth deformities such as burls, brooms, leader proliferation and stunting. Other injury includes delay in growth and leafing out and interference with nutrient up-take and storage. What actually happens is the frost kills the tissues in localized parts of the stem and causes a weakening of the cells of the cambium around or below the killed portion. If the frost condition is such that the stem freezes all the way around or is girdled, dieback occurs but if the tissue on only one side of the stem is frozen a canker will form at that spot. It takes only two or three days for these symptoms to become visible. The cambium below the dieback and around the canker in the still-living part of the stem is damaged but not killed and subsequent growth of these tissues is abnormal. Shoot dieback results in growth proliferation on the lower living parts and gives rise to candlebra, forked leaders with narrow crotches and in extreme cases round crowns and a permanently stunted condition. Frost cankered stems can be very strong when vigorous burls and frost ribs form around and over the damaged parts in much the way as in spruce. Spruce burls are highly prized for decorative purposes such as lamp or gate posts but poplar burls are usually rough and unattractive.

Gall and Rough Bark of Poplar:

The causal fungus (*Diplodia tumefaciens*) infects current and older woody stems including branches and main roots of all species of poplar and their hybrids. It can survive on a living host indefinitely. It does not kill the cambium but stimulates it to produce abnormally large amounts of inner bark and sapwood containing deformed cells. Its fruitifications produce water-dispersable conidia and air-dispersable ascospores. Infections result in galls or burl-like swellings that per-



Gall and rough bark caused by Diplodia tumefaciens

sist indefinitely on branches but not on the main stems where clearwood usually overgrows the tumors. Precautions to reduce infection include: planting poplar away from diseased trees, pruning and burning infected branches and removing severely infected trees.

Septoria Canker and Leaf Spot

The causal fungus (*Septoria musiva* Pk.) infects and kills living cells in leaves and thin bark of nursery trees of most poplars except aspen. It is not perennial and renews itself by annual infections that result in a localized leaf spot and in a canker affected only after the cambium is killed. The fungus does not infect thick bark, nor cause economic losses in fully established or mature trees as once thought. The canker reduces the quality of the seedlings, rooted stock and whips utilized for cuttings. Infections occur during the short warm growing season and cease when cool nights and early frost effect an early leaf drop. The fungus overwinters on fallen and attached leaves and produces mature air-borne ascospores in the spring.



UTILIZATION of POPLAR

The Resource

Interest in poplar as a commercially important species has existed across the prairies and, for that matter, in North America for some several decades, as match splints, lumber and lumber type products, peeler logs, pulpwood and fuelwood. More recently greater attention has been given poplar in the area of pulpwood and other fibre products such as flakeboard, particle board and similar products. Recent investigations have indicated that aspen fibre has a potential use in livestock diets.

Even greater consideration of poplar as a commercially important species, in league with spruce, pine and fir, is evidenced by the number of seminars, symposiums and conference held in the past ten years on the utilization of poplar.

In the prairie region of Canada (Manitoba, Saskatchewan and Alberta) recent forest inventories indicate a volume of 355 million cunits* of poplar. This volume includes both the trembling aspen and balsam poplar species. The percent-

age of balsam poplar included in this volume varies from province to province and ranges from 13 percent in Manitoba to approximately 20 percent in Alberta. It is included in this analysis because it is harvested commercially for various products and in varying amounts in each of the provinces.

The volume of poplar expressed in terms of annual allowable cut amounts to 6.2 million cunits.

Harvesting Levels

The harvest of poplar on the prairies is directed at the manufacture of conventionally or well-known primary wood products. Lumber, veneer, various types of particle board, flakeboard or wafer board, pulpwood in round and chip form and fuelwood. In past match splints were produced in Manitoba.

The current utilization level of the poplar resource in the prairie region is approximately 227,400 cunits annually. This amounts to about 3.7 percent of the annual allowable cut. Saskatchewan harvests the great-

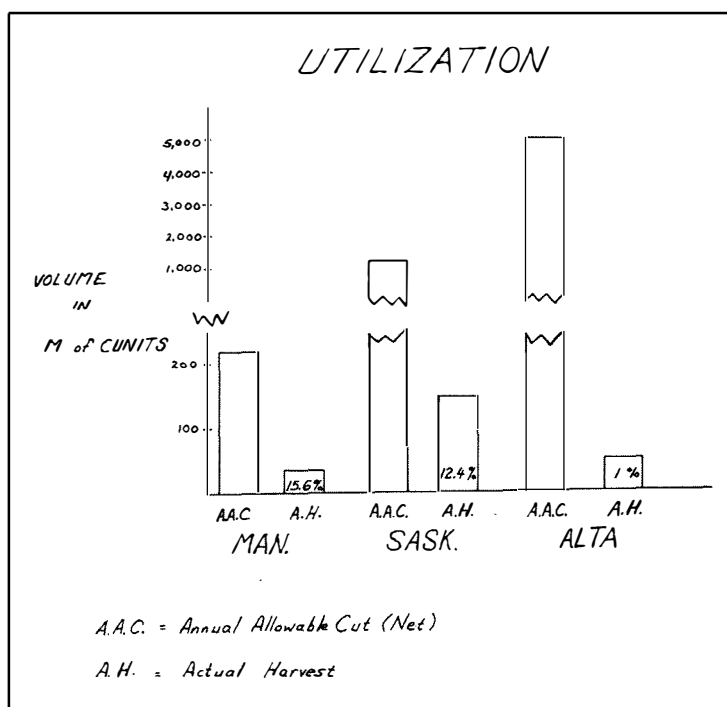
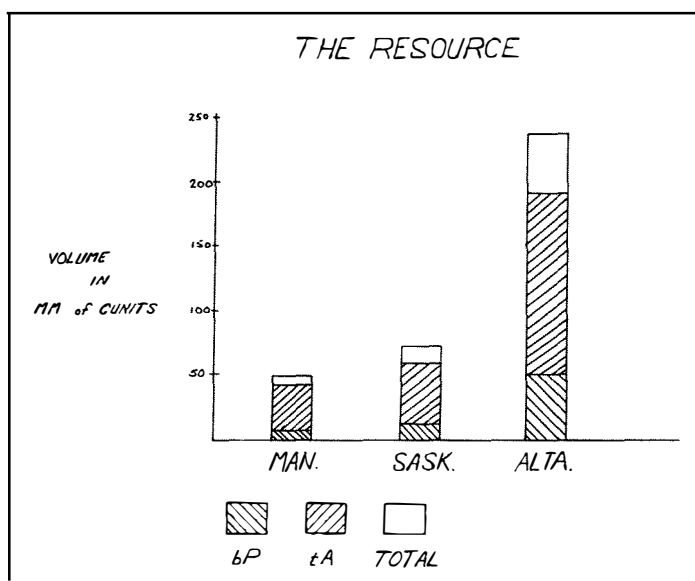
est volume of poplar of the three provinces (144,500 cunits), approximately triple that of Alberta and four times that of Manitoba.

Secondary and tertiary manufacture of primary products include plywood, studs, poplar slugs, grain doors, furniture components and furniture, fish boxes and other containers, insulation material, various forms of exterior and interior sheathing pallets and sewer cribbing.

An aspect of utilization that should be considered is that pertaining to provincial policies in the management of poplar stands. Provincial policies in the past can be briefly summarized by saying that if a market existed producers were awarded volumes deemed necessary to meet the demand. The best quality trees were selected from stands over a two or three cut cycle. Only the best logs of each tree were used unless producers had markets for top and poorer quality logs.

The management trend today is towards complete utilization of

*A measure of wood, equal to 100 cubic feet of solid volume. One cunit equals about 1.17 cords.



whole trees and stands. Poplar sites are reforested more easily and economically to an optimum level of stocking using a clear cut harvesting method. Logging equipment in the bush today aids the attainment of this objective.

Poplar Management policies on the prairies can be summarized thusly.

- Clear cutting of all poplar sites.
- Limiting the overall size of clear cuts and the management of poplar on an acreage basis.
- Utilization to minimum top diameters of four (4) inches inside bark.
- Utilization of individual logs containing up to 50 percent rot.
- Utilization of logs with external defects (crook, sweep, etc.)
- The integrated use of all species (coniferous and deciduous) in mixed wood stands.
- Cutting and operating plans prepared by producers, and approved by forest services, identifying the maximum but sustained utilization of poplar on their licence areas.
- Where applicable insistence on the

development of manufacturing plants capable of using both deciduous and coniferous species.

- The utilization of trees in poplar stands to minimum stump diameters.
- Penalties for under cutting allowable cuts of poplar volumes set out in management areas plans and licences.
- The responsibility of producers to participate in active reforestation programs.
- Encouraging the use of poplar through the application of rates of dues that are slightly lower than those for coniferous species.

REFERENCES

Jackson, C., 1974 *The deciduous timber resource and forest management Policies of Alberta*, 10 pps. Paper presented to Poplar Symposium, Edmonton, Alberta, May, 1974.

Millar, M. C., 1974 *Poplar management in Saskatchewan*, 10 pps. Paper presented to Poplar Symposium, Edmonton, Alberta, May 1974.

Rannard, C. D., 1974 *Poplar Management in Manitoba*, 7 pps., Appendix 10 pps. Paper presented to Poplar Symposium, Edmonton, Alberta, May, 1974.

<u>FIGURES USED</u>			
Saskatchewan	balsam poplar	10,663,610 cunits)	69,115,500
	trembling aspen	58,451,890 cunits)	
Manitoba	balsam poplar	5,940,000 cunits)	46,097,142
	trembling aspen	40,157,142 cunits)	
Alberta	balsam poplar	48,000,000 cunits)	240,000.000
		192,000,000 cunits)	
<hr/>			
	<u>Allowable Cut</u>	<u>Actual Harvest</u>	
Saskatchewan	1,164,500 cunits	144,500 cunits	
Manitoba	223,230 cunits	34,928 cunits	
Alberta	4,800,00 cunits	48,000 cunits	

Hybrid Poplars in the Forest Zone of Saskatchewan

The Northern Forest Research Centre obtained white, gray and trembling aspen hybrids from the Research Branch of the Ontario Ministry of Natural Resources in the spring of 1971, to test their adaptability to the harsh climate of central Saskatchewan.

Cuttings were rooted in pots and outplanted in the Prince Albert nursery, Saskatchewan. Although height growth was impressive during the first growing season (average of 27"), the current growth was not hardened off when first frost occurred in the fall and all plants were top-killed. In 1972 more cuttings of these hybrids were obtained and planted in the nursery. During the

following winter all plants were completely killed, probably due to the lack of deep snow cover. It appears from this trial that hybrids of white, gray and trembling aspen, originating from Europe, Asia and North America, are not hardy in central Saskatchewan.

In 1971 and 1972 the Forestry Branch planted the following hybrid poplars developed for the Prairie Provinces on recent cut-over areas of MacMillan Bloedel Company Limited in Hudson Bay, Saskatchewan.

Saskatchewan poplar
Walker poplar,
Vernirubens poplar
Brooks No. 1
Trembling aspen (local)
Gelrica poplar

Dunlop poplar
Northwest poplar

Some of the planting sites were cultivated prior to planting. This preparation was beneficial for both survival and subsequent growth of the rooted cuttings, especially on the older cutovers. Where natural aspen suckering provided shelter, rabbits caused considerable damage to the planted material.

Based on preliminary observations by the Saskatchewan forestry branch, Northwest, Vernirubens, Saskatchewan and Walker showed best performance in terms of survival, hardiness and height growth. These results provide only early indications on the performance of hybrid poplars under forest conditions in Saskatchewan.

WOOD PROPERTIES cont'd.

TABLE 1. Major Wood, Pulping and Pulp Characteristics^a

Characteristic	Trembling Aspen	White Spruce
Specific gravity	105	100
Pulping rate	165	100
Alkali consumed	95	100
Pulp yield	125	100
Pulp strength ^b	70	100

^a Relative to white spruce arbitrarily designated 100.

^b An average factor based on tear factor, burst factor and breaking length.

Excessive amounts of cubical rots could seriously affect yield and quality of poplar kraft pulps. However, 10% white rot is probably acceptable. White rot is the common decay in poplar and only the advanced stages present a problem in pulping.

Poplar could be mixed with common softwoods in the kraft process up to a proportion by weight of 10% without any detectable decrease in strength properties. However, technical disadvantages would include the maintenance of a constant hardwood: softwood chip feed ratio, and selection of the most suitable pulping schedule to minimize the effects of different pulping rates. There might also be problems with customer acceptance of mixed hardwood-softwood kraft pulps. The mechanical pulps and specifically the chemi-mechanical pulp from

poplar show excellent tear factors compared with white spruce and would find major outlets principally as newsprint, but also as magazine and book stock.

Fibreboards, a product of the mechanical pulping process, can be manufactured just as well or better from poplars as from softwoods because of their low density and good quality fibres. However, due to economic and market factors, the potential for greater use of poplars in fibreboards is somewhat limited at present.

The rapid growth rates in the particleboard industry, and the preference for relatively low-density species in particleboards, promises increased use of the poplar resource in these products. The good compressibility of poplars at low pressures results in a board with a smooth surface and adequate strength at low density. In Canada, waferboard has recently emerged as the fastest growing segment of the particleboard industry, and all existing and planned production is from poplar roundwood.

The potential for increasing poplar plywood production is not high because of inadequate supplies of high quality logs, and a number of production difficulties caused by tension wood, wet pockets, ring shake and soft cores.

Lumber production, particularly factory lumber, has been limited, because of high decay incidence and small diameter stands. Recovery for framing lumber is more promising.



Aspen lumber

Studies indicate that a satisfactory recovery of 2-inch construction lumber is attainable from at least 75% of the merchantable volume of most trembling aspen stands. In lumber strength, the "northern aspen" species group (including trembling and largetooth aspen, and balsam poplar) is similar to the "spruce-pine-fir" species group, and for many uses the two groups are interchangeable. Although the drying of poplar lumber presents some difficulties due to the presence of wet pockets, one commercial schedule has recently been developed, and further work is underway.

Because it lacks highly toxic extractives, poplar wood is quite susceptible to decay under conditions favoring fungal growth. However, indications are that, if properly dried, aspen will take preservatives equally well or better than most softwoods. Hence there exists the potential of using preservative-treated poplar in applications which require decay resistance.



Environment
Canada

Environnement
Canada

Forestry
Service

Service
des Forêts

Contributors to this issue of FORESTRY REPORT: Dr. G. A. Steneker, Officer in charge Winnipeg Sub office Northern Forest Research Centre. Dr. W.H. Cram and R. Esau, Tree Nursery, P.F.R.A. Indian Head, Saskatchewan. J. Soos, Northern Forest Research Centre, Edmonton. Dr. J. V. Hatton and R. Neilson, Western Forest Products Laboratory, Environment Canada, Vancouver. Dr. H. R. Wong, and H. Zalasky, N.F.R.C. Edmonton. Mr. C. O. Rannard, Manitoba Department of Mines, Resources and Environmental Management. Winnipeg.

FORESTRY REPORT is published by the Northern Forest Research Centre, Canadian Forestry Service, Environment Canada, 5320 - 122nd Street, Edmonton, Alberta T6H 3S5. For further details concerning articles in this issue address the Director or Information Officer.