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SILVICULTURE AND MANAGEMENT OF ASPEN IN CANADA: THE WESTERN CANADA SCENE

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ABSTRACT.--After a brief review of the aspen resource in British Columbia, Alberta, Saskatchewan and Manitoba, and highlights of recent trends in aspen utilization, the paper reviews aspen regeneration and silviculture, density management, growth and yield predictions, and present and future challenges in aspen management. The future of the aspen resource in relation to industrial development, silvicultural practices and possible greenhouse effects are also covered.

INTRODUCTION

For clarification purposes a summary of the contents of this paper follow:

- Aspen regeneration for hardwood production
  - After harvesting hardwood stands
    - Improvements in aspen regeneration
  - After harvesting mixedwood stands
    - Prediction of aspen regeneration
- Stand density management and stand productivity
  - Growth and yield predictions
- Challenges in aspen management and silviculture
  - Land use allocations for hardwood and softwood production
  - Need for improved inventory of the hardwood resource
  - Hardwood decay - utilization relationships
  - Quality of second-growth stands
  - Rehabilitation of high-graded and overmature stands
  - Management of balsam poplar component
  - Wildlife implications of changing hardwood management
  - Public concerns about changing hardwood management
- Aspen management in western Canada in the future
  - Aspen resource and industrial developments
  - Improvements in aspen regeneration and silviculture
  - The greenhouse effect and aspen management
  - Future aspen resource

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At the 1972 Aspen symposium Dr. Keays (Keays 1972) in his leading paper suggested that in Canada:

> the aspen cut is small and is not increasing appreciably. No change in this trend is anticipated in the near future. Even by the turn of the century it is likely that less than half of Canada's annual allowable cut of aspen will be utilized.

The last few years are proving this to be an understatement. Indeed, the rapid increase in aspen utilization, particularly in western Canada, far exceeded most of our expectations.

As a result, aspen is no longer considered a weed species. Quite the contrary, aspen in the west is now heralded as the "Queen of the forests," the "champion species," and the "star of mixedwood management."

One thing did not change; Canada still has an abundant aspen resource of about 2981 million m^3 growing stock, and an estimated Annual Allowable Cut (AAC) of about 45 million m^3 -- other hardwoods make up another 15 million m^3. The four western provinces -- British Columbia, Alberta, Saskatchewan, and Manitoba -- together have 16.3 million m^3, or about one third of the country's AAC; with Alberta contributing about one half of this (Fig. 1).

In this paper we synthesize the latest information available on aspen regeneration and silviculture and problems and challenges in growing this crop, then speculate about the future of aspen management in western Canada.

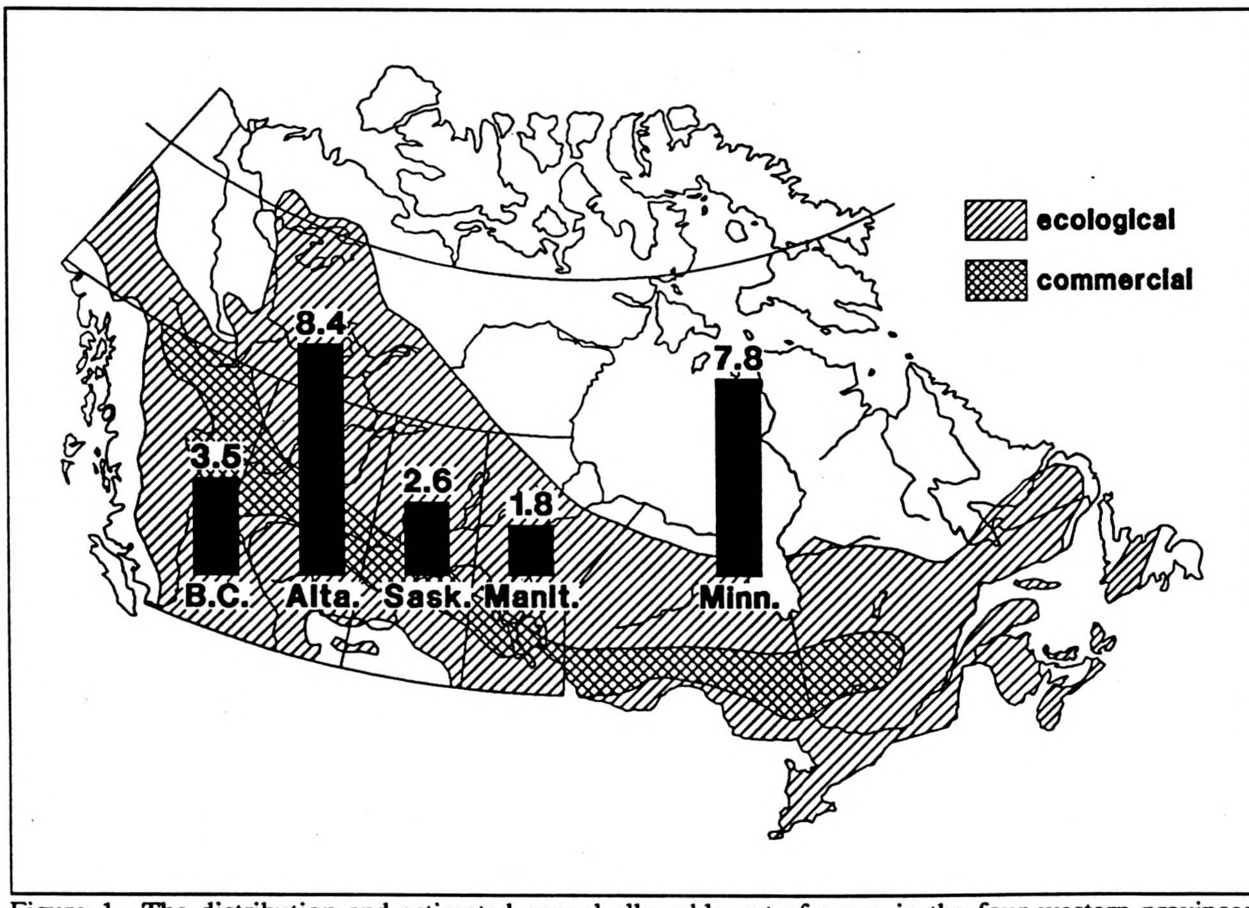

Figure 1.--The distribution and estimated annual allowable cut of aspen in the four western provinces.

AFTER HARVESTING HARDWOOD STANDS

In western Canada, large scale harvesting of aspen stands started in the 1960s for flakeboard manufacturing in east central Saskatchewan. In that area, the harvested stands were almost pure aspen, growing largely on fairly level lacustrine deposits. Clearcutting was done throughout the year with wetter sites scheduled for winter harvest. Falling and delimbing with chainsaws and full-tree skidding with tractors in the 1960s and 1970s caused little soil compaction and root disturbance and generally resulted in adequate sucker density and stocking and no substantial problems in aspen regeneration.

In the same area, a research study (Bella and DeFranceschi 1972, Bella 1986) found excellent stocking (nearly 100%), and aspen density ranging from 50,000 to 150,000 suckers/ha. Large initial differences in densities due to season of logging (viz., winter or summer) and slash load diminished to a narrow range 5 years after harvest. The results implied flexibility in harvest scheduling and method of logging. Observations from other areas in the boreal forests of western Canada confirmed the relative ease of obtaining adequate aspen regeneration after clearcutting pure aspen stands on fresh upland sites.

General guidelines for regenerating aspen stands, and silvicultural manipulation of aspen clones were worked out in the region in the early 1970s (Steneker and Wall 1970, Steneker 1974, 1976). Much additional information about aspen silviculture and management is available in review and research papers from other regions in Canada and the United States (e.g., Doucet 1989, Davison et al. 1988, Debyle and Winokur 1985, Perala 1977). In the last 10-15 years, most information on aspen silviculture was concerned with its density control and its competition with conifer reproduction (e.g., Johnson 1986). Information on aspen regeneration within a regional context is covered by Steneker (1976) and Navratil and Bella (1989). Currently, Forestry Canada, Northern Forestry Centre, Edmonton, is compiling all available knowledge on aspen management in a monograph to be published in December 1989 (Peterson and Peterson 1990).

There are some factors in aspen regeneration that appear to be particularly important in western Canada's mixedwood forests. Among these, soil temperature and practices affecting it, may be the most important. In this region with cold soils, the removal of shrub layers by summer logging raises soil temperature, and as a result seems to enhance suckering and initial sucker density (Bella 1986). In stands with a heavy shrub layer, full tree logging and anchor chain treatment will destroy shrubs and reduce soil shading (Steneker 1976). Schier (1976) suggests that in northern areas, soil temperature may be more critical to aspen reproduction than carbohydrate reserves, which are important in the warmer, southern regions. These differences may explain conflicting recommendations concerning the beneficial effect of winter harvesting on density of aspen sucker regeneration (Heeney et al. 1975).

Improvements in Aspen Regeneration

Some problems in aspen regeneration have been observed on upland hardwood sites. Multiaged, patchy aspen regeneration after high grading, unexplained differences in aspen density in response to site treatments, and insufficient stocking of aspen regeneration ascribed to soil compaction and root disturbance from logging have all been noted to a variable degree in the region.

The recent upsurge in logging of several cover types that contain aspen has increased the awareness of aspen reproduction and the need for improved management in the region. Forest managers have come to realize that satisfactory aspen regeneration may not be free after all, and aspen regeneration may even need to be encouraged (Smith 1989). It should also be noted that widespread harvesting of the aspen resource, particularly in mixedwood stands, is so recent that only a few regionally specific problems have been identified. Appropriate regeneration strategies and silviculture methods are yet to be developed, or adopted from other regions. A survey of the aspen-using industry and the provincial governments in the region suggests broad support for improvement of aspen regeneration and for more intensive management of the aspen resource generally.

In most of western Canada, the majority of "pure" aspen cover types consist of mixed aspen-balsam poplar stands. At present, the demand and harvest of balsam poplar is rather limited, resulting in substantial amounts - as much as one third of the original basal area - of residual poplar left standing in aspen cutovers (Peterson et al. 1989, Peterson 1988, Denney 1987). The presence of these poplars hinders aspen suckering and site preparation, and will likely increase balsam poplar regeneration while slowing aspen sucker growth. Detailed regeneration surveys are required to fully assess the impact of residual balsam poplar. Other issues and challenges of balsam poplar management in the context of aspen management are addressed later in this paper.

The past practice in some areas of removing superior aspen trees (high grading), resulted in aspen stands with uneven aged structure, irregular and poor regeneration, and abundant brush layer. There is a similar situation in overmature, decadent hardwood stands that also lack vigorous aspen regeneration. Past underutilization and efficient fire protection have shifted age class distribution of aspen and mixedwood stands towards older age classes. The challenges of rejuvenating high-graded and overmature stands, and their successful regeneration and rehabilitation to full production are discussed later.

Locally observed problems of inadequate aspen regeneration related to logging are easy to rectify. Forest managers in the region are aware of these problems and intend to adopt harvesting schedules and methods that limit soil compaction and root disturbance (unpublished survey by the authors). Landings lacking aspen regrowth are planted with conifer seedlings to maintain forest production, as well as to improve aesthetic values and increase ecological diversity. Planting of native or superior aspen and hybrid poplar is anticipated when production of poplar and aspen planting stock becomes justified and available (Smith 1989).

AFTER HARVESTING MIXEDWOOD STANDS

More serious problems, as well as land use conflicts relating to aspen regeneration and management, emerge where aspen is harvested in mixedwood stands. In the Boreal Mixedwood Region, aspen grows in admixtures with other species; aspen-pine (jack or lodgepole) and aspen-spruce (primarily white spruce) are the most important in this review. On a regional basis, approximately 30 percent of aspen AAC is in the mixedwood cover types. On a productive land area basis, the proportion of aspen can be much higher - e.g., in Alberta 50 percent of the productive land area that supports aspen is in mixedwood stands (Clark 1988).

Mixedwood cover types occur over a wide range of moisture regimes, soil textures, and organic layer thicknesses, all of which affect, either directly or indirectly, density and growth of aspen regeneration through effects on soil temperature and herbaceous and shrub cover. Often on the most productive mixedwood sites, a thick duff layer, a rise in the water table after harvest, low soil temperature and invasion of alder and willow competition may hinder aspen regeneration. On such sites, the balsam poplar component often increases compared to the original stand (pers. comm. R. Brooks, D. Sidders, 1989).

In this context, ecologically based site classification that also incorporates soil moisture dynamics may be particularly useful in mixedwood management, because aspen productivity and stand response to logging, site preparation, and regeneration practices are all site-related and predictable (Corns 1988). Ecological site classification systems that include some management and silvicultural interpretations pertinent to aspen regeneration, productivity, and competition are available for some areas in the region: e.g., for west central Alberta (Corns and Annas 1986) and for northeast British Columbia (DeLong 1988).

With increased aspen-mixedwood utilization, management regimes and guidelines for the renewal of mixedwood stands are currently the subject of reviews, discussions, and modifications (Beck et al. 1989, Henderson 1988). Policies relating to forest renewal have been historically biased in favor of conifers. These now have to recognize that aspen and other hardwoods are used and have value. Aspen regeneration objectives thus ought to be reflected in forest management goals and depend on whether aspen regeneration is to be encouraged as a future hardwood resource, tolerated, or suppressed in favor of mixed or conifer regeneration. The issues affecting the choice of aspen regeneration strategy encompass biological considerations such as site productivity potential for the species and regeneration performance, as well as policy and regulation issues.

Prediction of Aspen Regeneration After Harvesting Mixedwood Stands

Foresters making decisions concerning the regeneration phase of mixedwood stands need to predict the density of future aspen regeneration after the present stand is harvested and evaluate the new stand's potential for hardwood production. Conversely, when managing mixedwood areas for softwood production, foresters need to estimate aspen competition as an obstacle to conifer establishment. Such prediction relationships have to be based on local and regional data on the composition and density of aspen in the parent stand, site relationship and so on. In Minnesota, Perala (1977, 1983) found that 120 parent stems per ha are needed to produce fully stocked stands, and 40 parent stems per ha are needed for minimum stocking of 60 percent. Doucet (1979, 1989) suggests that in Quebec, full aspen stocking can be achieved with a basal area of 5 m^2/ha in the parent stand as long as the aspen stems are no more than 8 to 10 m apart.

In northern Alberta, Forestry Canada in Edmonton, has initiated a study to quantify aspen regeneration and ingress of sucker and seed origin on cutblocks following harvest of pine-aspen and pine cover types. Data from field surveys document areas restocked by suckers from a single aspen tree (Fig. 2) and density of seed origin aspen by site type (Fig. 3). Work is in progress to develop a silviculture decision model for predicting aspen regeneration to facilitate ranking areas for hardwood and softwood production and silvicultural treatments.

Regional surveys indicate that despite the strong interest and efforts to grow and manage conifers, most sites end up with mixed regeneration because of aspen encroachment either by suckering or seeding-in. In addition to the concerns about a potential gradual shift from the boreal mixedwoods to boreal hardwoods (McDougall 1988, Rowe 1989, Peterson et al. 1989) there are lingering uncertainties about the future development of mixed regeneration and its long-term effects on softwood and hardwood AAC. Our forecasting abilities on stand development of mixed regeneration and on interactive growth of aspen and conifers in the mixture are very poor. It is essential to obtain such information with suitable linkages to long-term wood supply projections.

STAND DENSITY MANAGEMENT AND STAND PRODUCTIVITY

As mentioned before, aspen cutovers generally produce very dense regeneration. Although the amount of logging slash on the ground and season of logging results in substantial differences in initial sucker density, these differences in density largely disappear by 5 to 10 years of age (Bella 1986). This means that more young trees die when growing under dense conditions than growing in open stands; and this trend seems to continue at least during the early stand development stage.

This self-thinning tendency of aspen stands has important implications regarding stand tending. Unlike some intolerant pine species, aspen even at high initial densities will maintain the usual rapid height growth and reasonable diameter growth and will produce maximum total wood volume (Bickerstaff 1946, Jarvis 1968, Schlaegel 1972). However, reducing excessive density at a young age by thinning can substantially accelerate diameter increment of crop trees, enhance the earlier production of usable

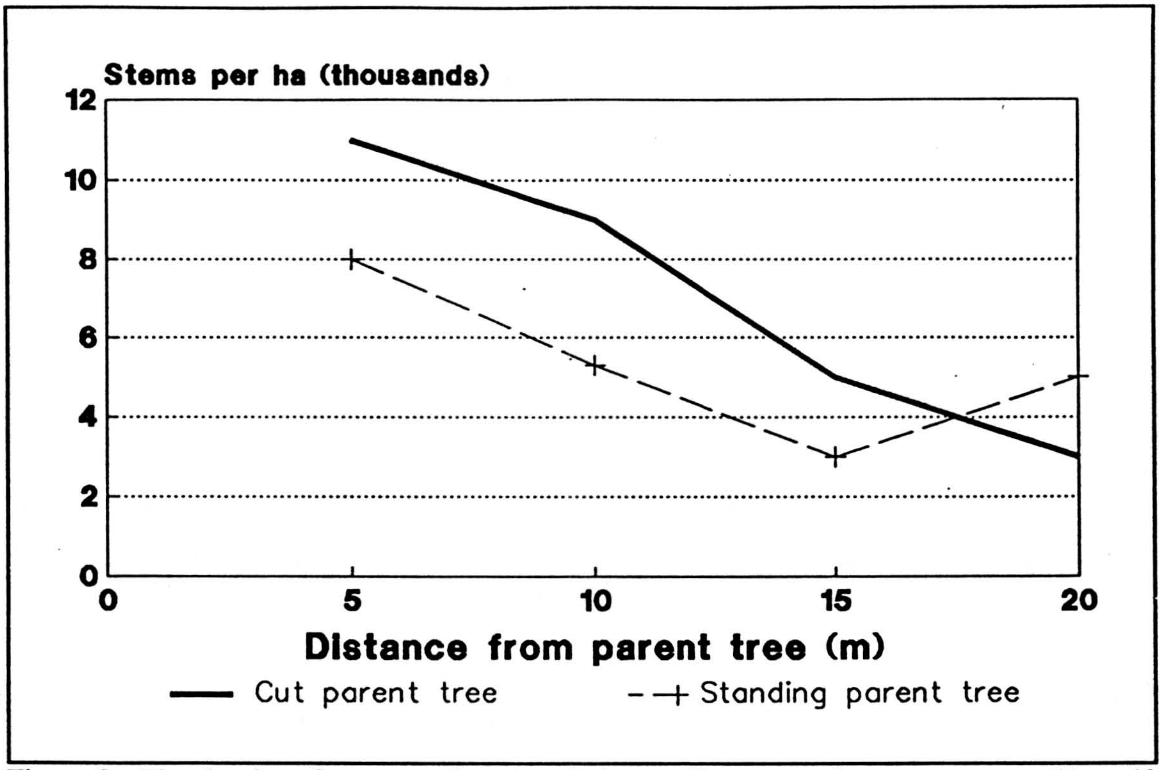

Figure 2.--The density of aspen suckers in relation to distance to the parent tree at 11 to 13 years after harvest from Grande Prairie region, Alberta.

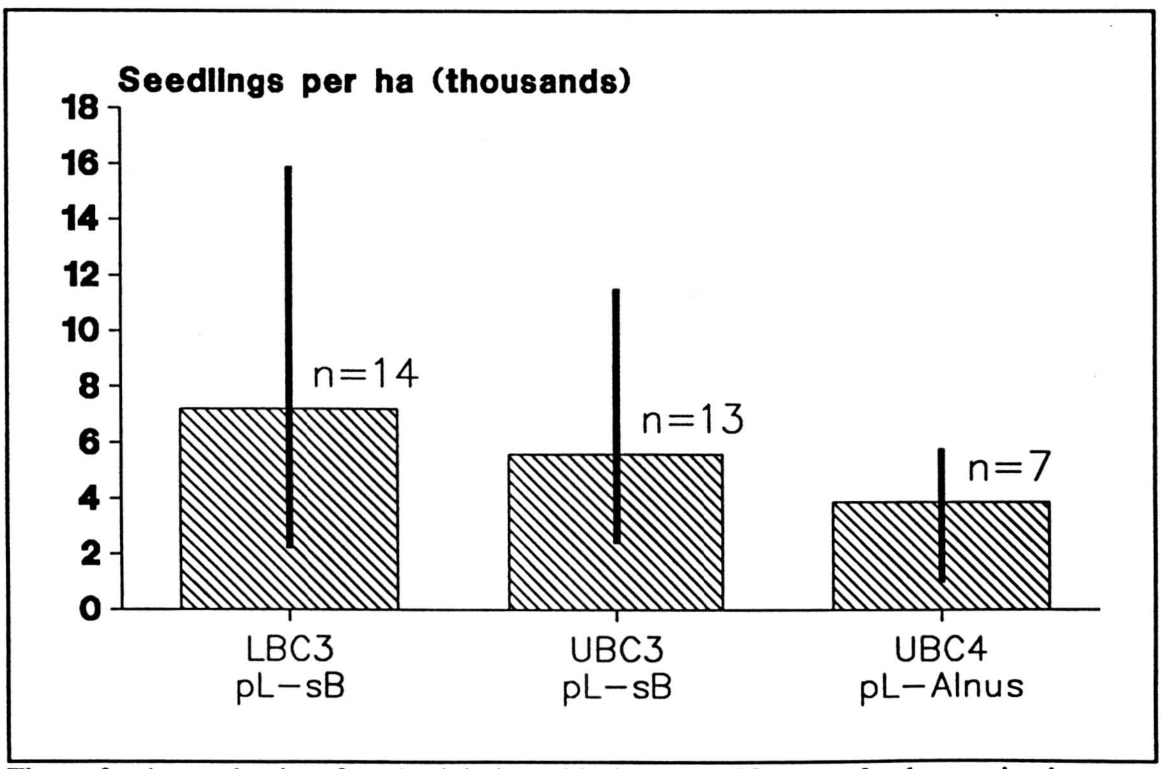

Figure 3.--Aspen density of seed origin in cutblocks at 7 to 20 years after harvest in pine cover types, bars indicate the ranges. Ecosystem associations after Corns and Annas (1986).

material (Bickerstaff 1946, Schlaegel 1972, Perala 1978) and thus reduce rotation length. As decay losses rapidly increase with age, shorter rotation will tend to reduce such losses.

Although thinning may thus somewhat enhance the production of larger, sawlog size material, the production of total stem volume, or merchantable volume to close utilization standards (e.g., pulpwood or similar size timber) is generally adversely affected by thinning (Bickerstaff 1946, Jarvis 1968, Mowrer 1987). This is also well illustrated by the latest growth data at age 59, from one of our aspen thinning experiments from west-central Manitoba established 36 years ago on relatively good growing sites. These experiments also show the greatest total stem volume production in unthinned stands, and declining production with increasing thinning intensity (Fig. 4).

Tree growth characteristics and associated stem quality, as well as insect and disease resistance generally have a strong genetic component and thus provide an opportunity to improve stand quality through judicious tending practices. Undesirable clones, whether because of poor growth habits or disease susceptibility, can be identified and removed. This "sanitary thinning" may be feasible in aspen stands where trees of different clones are intermixed rather than grouped (Navratil 1987).

In planning any silvicultural activity including stand density control treatments, the chief consideration is the most effective production of usable wood for harvest. At present the prime use for aspen timber in Western Canada is oriented strandboard (OSB) and pulp manufacture; and there is no reason to expect any major shift in utilization.

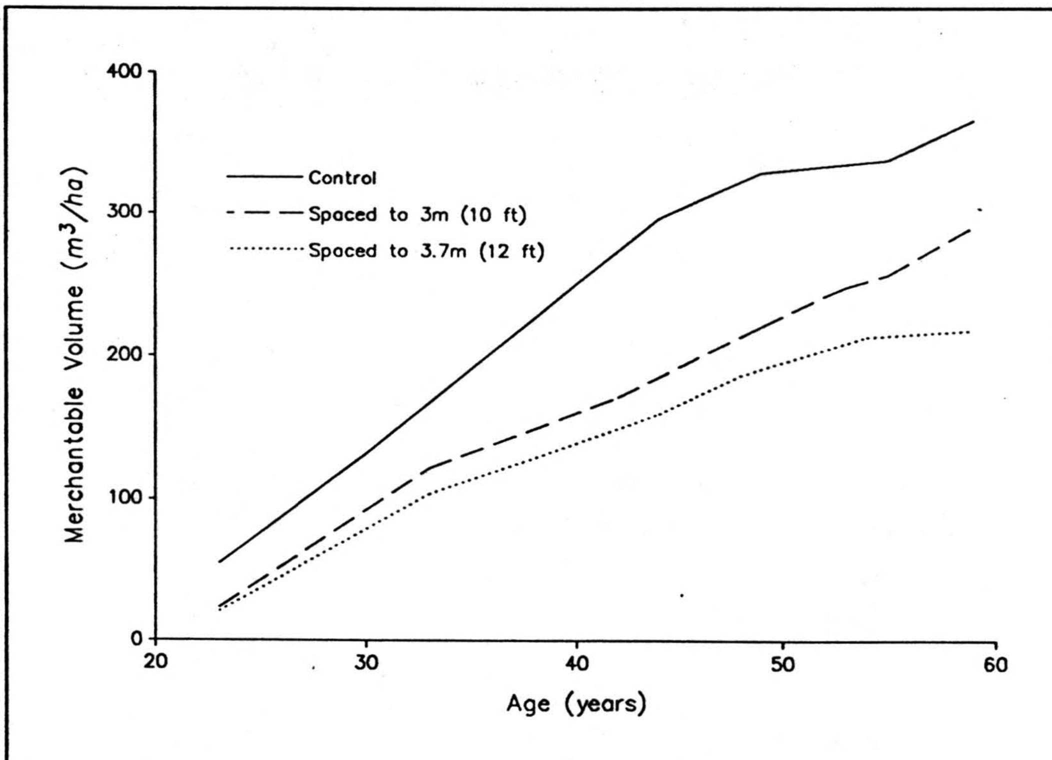

Figure 4.--Merchantable volume of aspen at three density levels. Thinned at age 23 to 3 and 3.7 meter spacing and untreated control. Merchantable volume: stump height - 15 cm and top dib - 8 cm.

Thinning young aspen stands does not enhance pulp- or OSB-wood production; if anything, it has the opposite effect. If one also incurs considerable treatment costs -- at present at least $300/ha in Western Canada -- to be carried to the end of the rotation, thinning clearly becomes an unviable option.

Another important consideration in thinning aspen is this species' susceptibility to stem infections and decay from even minor thinning injuries. Thin bark and the lack of a strong protective response, are the main reasons. Decay from wounds can spread quickly and usually means the loss of the most valuable part of the stem.

A related problem is what appears to be an increased incidence of Hypoxylon canker in heavily thinned stands, as noted by Anderson and Anderson (1968) and others, and covered in this symposium by Ostry and Anderson. We also observed the increased incidence of cankers and top damage in two aspen thinning trials -- 35 and 59 year old stands-- in the Porcupine Mountains of west-central Manitoba and east-central Saskatchewan.

Another problem that can arise in thinned aspen stands is sucker initiation and establishment of shrub and herb layers induced by canopy opening and inherently loose open crowns. Although understory aspen suckers generally succumb, the shrub layer may persist and thrive, especially as the stand ages. This creates difficulties in regenerating aspen following harvest.

In some situations, providing forage for grazing domestic livestock is an important consideration, and opening up aspen stands by thinning may be viewed as a possible solution. This is probably an undesirable option as the shallow rooted aspen may suffer both from direct physical damage to roots and soil compaction caused by livestock. On the other hand, thinning aspen might be desirable where amenities such as access and appearance are main considerations, e.g., in campgrounds and parks, and in stands adjacent to roads and trails used for recreation. Thinned stands have a neat appearance and are generally more suitable to various recreation pursuits at an earlier age than unthinned stands. The cost of treatment is also easier to justify for such uses.

GROWTH AND YIELD PREDICTIONS

Procedures described here are those used in the four western provinces to update forest inventories and to project growth and yield of stands to rotation age for AAC calculations. All these procedures are based on information from old growth, natural untreated stands and should be suitable for aspen in most cases with the possible exception of east- central Saskatchewan where there are now large areas of second growth aspen stands that originated after harvesting old growth for flake-board manufacture. The interim modelling assumption for growth and yield prediction in these stands is that they will produce at least the same yield at rotation as former old growth stands.

In British Columbia, Variable Density Yield Tables have been developed by the Forest Service (BCMOF 1983) for all commercial species growing in pure stands. A lack of crown closure estimates for all polygons in the inventory, however, has prevented their implementation. Until 1989, an interim system was applied to update inventory statistics and calculate AAC. The system utilizes temporary (inventory) and permanent sample plot data fitted to a non-linear yield model -- a reformulation of the Chapman-Richards function following Ek (1971)-- with age and site index as independent variables.

Volumes to different merchantability/utilization levels are estimated using volume ratios derived from a hyperbolic function using the same independent variables. As crown closure information is now available in the forest inventory throughout the province, a revised growth and yield prediction system based on the variable density approach using connected permanent growth plot data is being developed for implementation in 1990 (pers. comm. J. E. Vivian, June 1989).

In Alberta, the Forest Service uses empirical yield growth curves for the major cover types developed for each Volume Sampling Region (VSR) (Alberta Forest Service 1985) to update inventories and project yield of stands to rotation age. Each VSR represents a group of townships with similar biogeoclimatic characteristics and 11 of these cover the province's forested areas. The yield curves represent average fully stocked stands, i.e., C and D density classes. In using these yield curves, no allowance is made for the understocked stands to approach fully stocked conditions, so yields tend to be underestimated. Work is in progress to develop a new system of yield forecasting that would account for the "trend towards normality".

In Saskatchewan, where conditions are fairly uniform in the commercial aspen zone, mature and overmature aspen volumes are determined directly from the forest inventory data, and immature stands are "grown" using a fixed yield value derived from present mature stands. This fixed yield is also used to determine Long Run Sustained Yield, which is assumed to be the best estimate of the second rotation harvest levels (pers. comm. D. Dye, 1989).

Manitoba uses a similar approach. Mean annual increment values are obtained from the forest inventory, then they are used in conjunction with stand tables, volume tables, and area summaries to calculate annual allowable cut. They are enhancing their inventory as budgets permit, and will be moving towards improvements in yield forecasting, be it traditional variable density yield tables developed for the purpose, or locally calibrated versions of complex simulation models (pers. comm. G. Peterson, 1989).

In the regional scene, the Northern Forestry Centre in Edmonton conducts research and development in Alberta, Saskatchewan, Manitoba, and the Northwest Territories, and has been active in aspen growth and yield work over the last thirty years. Several thinning experiments have been established and monitored over the years and the results published. Temporary sample plot yield data for aspen were also collected and preliminary yield tables constructed for Alberta and Manitoba; while in Saskatchewan the provincial forest service developed and published yields tables for this cover type (Kirby et.al. 1957). Recently some of our long term aspen growth data were used to test STEMS (Stand and Tree Evaluation and Modelling System, e.g., Miner and Walter 1984) in the region for natural fire origin, untreated stands and for thinned stands. For both conditions the model gave reasonable predictions.

CHALLENGES IN ASPEN MANAGEMENT AND SILVICULTURE

Not surprisingly, increasing interest in the aspen resource in western Canada is revealing new challenges in its management and silviculture. These challenges have been grouped under ten key subjects as follows. The term 'hardwoods' is used to refer to both aspen and balsam poplar, but here it pertains mainly to aspen because that is the dominant hardwood species in western Canada.

LAND USE ALLOCATIONS FOR HARDWOOD AND SOFTWOOD PRODUCTION

Integration of softwood and hardwood harvests on the same land base by different users needs innovation. Experience to date is limited on how to successfully remove hardwoods from lands allocated to softwood licensees. Techniques to reduce damage to white spruce during hardwood harvesting were suggested by Froning (1980) and reviewed by Johnson (1986). More recently, Brace and Bella (1988) and Brace (1989) discussed harvesting methods to remove aspen while protecting the white spruce understorey.

In western Canada, criteria are not yet well defined to decide when the hardwood or the softwood resource carries priority in circumstances of overlapping tenure. Many realize that there are advantages to an integrated approach to softwood and hardwood harvesting from the same land base, such as reduced harvesting costs and better protection of the site, and improved regeneration as a result of better planning and operational control. It is also good public relations to demonstrate higher levels of utilization. In addition, market fluctuations for coniferous products can be dampened by markets for hardwood products (Denney 1988).

A whole new set of regulations and policies, harvesting and regeneration technologies, and ethics on the use of the existing stands and the regeneration of future forests on mixedwood cover types must evolve (Murphy 1988, Beck et al. 1989).

NEED FOR IMPROVED INVENTORY OF THE HARDWOOD RESOURCE

Recently, a committee in the British Columbia Ministry of Forests (BCMOF), which defined twelve current problems related to hardwood management, identified improved hardwood inventory and data on the relative proportions of hardwoods and softwoods in many mixedwood stands as the highest priority need (Revel et al. 1986). Furthermore, across the Mixedwood Section in western Canada, a need exists for better data on size and age class distribution of softwood regeneration beneath aspen overstories.

Earlier inventories often underestimated the balsam poplar component in aspen-balsam poplar stands. Recently, Minnesota and Alberta have been involved in a cooperative exchange of ideas on how to achieve better aerial photography for identification of hardwood species for inventory purposes (Westfield 1987).

The proper aging of hardwood stands remains a difficult problem, particularly in mature stands that have well advanced stem decay. In Alberta, recent re- aging of aspen with field laboratory equipment revealed that many stands originally classified as 120 years of age are only 80 years old, 80 year stands are only 60, and 60 year stands are only 50. For stands 40 years or younger, previous aging has been relatively accurate.

HARDWOOD DECAY - UTILIZATION RELATIONSHIPS

Decay and stain influences on aspen utilization continue to create uncertainty amongst those who produce, manage and use this resource in the west, but it is less of a concern now than it was a decade ago. The major problem remaining is predicting the amount of stain and decay in existing or future hardwood stands. Despite numerous aspen decay studies, the decay estimates in standing trees and prediction of cull remains a problem, partly because of the biological complexity of tree-decay relationships and partly due to incompatibility among the decay studies and inconsistencies among investigators (Basham 1987, Navratil 1987, Hiratsuka and Loman 1984). There are strong economic incentives for more accurate estimates of cull in aspen and balsam poplar and several studies are in progress. The Alberta Forest Service is searching for criteria that would aid identification of rot-free aspen stands and Forestry Canada, Northern Forest Centre is completing a field guide for aspen decay and stain identification (pers. comm. Y. Hiratsuka, 1989).

Some of the present anxiety about aspen use is based on a belief that much of the present volume will not be available because of rapid losses from stand break up, in addition to cull from decay, after 80 years of age (Dempster 1987). Realistic projections of aspen break up are one of the main requirements for more accurate determinations of AAC.

Aspen decay management will require policies different than those developed for softwoods, which in Alberta has been to schedule harvests first in the oldest and least healthy stands. The present forest inventory indicates that many Alberta aspen stands are too old or too young to use. As a result there is actually a relatively narrow range of age classes in which the trees are of suitable size and still without severe decay. Aspen management involves difficult decisions that are often influenced by the marketplace. Just as aspen managers cannot ignore the realities of aspen age-class distributions, neither can they ignore the effect of wood quality criteria upon the marketability of many products. The latter point is well documented by Kennedy (1974) and Wengert (1976).

QUALITY OF SECOND-GROWTH STANDS

Aspen stand quality following harvesting has not been documented in western Canada. In the absence of site specific studies within the region, one may assume that observations on pathological quality of aspen suckers from northern Ontario are applicable (Basham and Navratil 1975, Kemperman et al. 1976, Weingartner and Doucet in this Proceedings). Kemperman et al. (1976) concluded that the development of second growth aspen stands will probably not be seriously limited by defect until they are at least 40 - 60 years of age.

In view of frequent use of mechanical site preparation on mixedwood sites, root rot and stain defects, especially by Armillaria spp., are likely to be more common and more important in newly regenerated stands. Basham (1982, 1988) reported the increased stem and root defects in aspen suckers after heavy drag scarification.

There is very little literature on the influence of insects on young aspen stands. Webb (1967) indicated that in heavily stocked aspen stands the death of a number of the trees, particularly the suppressed and intermediate individuals most vulnerable to borer and fungi attack, will improve the health of residual trees.

There has been some concern that post-harvest sucker stands may be falling behind in desired stocking and distribution, particularly on mixedwood sites. Insect and disease infestations could have greater impact in future managed stands with lower sucker densities than in fire origin stands. In addition, productivity of these stands could be reduced due to lower stocking and density alone, and in combination with the pest impact.

REHABILITATION OF HIGH-GRADED AND OVERMATURE STANDS

There are aspen stands in western Canada where most remaining trees are decadent because of previous high-grading. This is most prevalent where aspen has been harvested for plywood. For example, near Hudson Bay, Saskatchewan, many stands may now be beyond any utilization potential. About 182,000 ha of mixedwood and 265,000 ha of pure aspen stands in Saskatchewan have reached such an overmature and decadent stage (pers. comm. A. Kabzems, 1988).

Uneven-aged stands can develop from other causes as well. The break-up of mature stands is one of these. Aspen stands that have escaped fire for 90 or more years may have an advanced understory of aspen, often in the range of 40 to 50 years, and there may also be even younger aspens in the shrub layer. The dynamics of these stands are poorly understood. Experience indicates that multi-aged aspen stands are the most difficult management challenge. The most direct remedy is conversion to single-aged stands. The challenges are to select the best silvicultural options to re-establish a new vigorous aspen stand and to select the "best" sites to do this. The criteria developed for the poplar working group in Ontario (Davison et al. 1988), and methods used for stand regeneration in Minnesota (Perala 1983, Jones 1987) may be applicable to western Canada.

It is more difficult to decide which are the "best" sites for aspen renewal. Because aspen prefers the same sites as the more valuable softwood species (Corns 1988, 1989), there is a dilemma about whether hardwoods or softwoods should be favored. Although aspen can occur as a dominant or codominant on a wide range of sites, Corns (1988) suggested that the choice between white spruce or aspen should consider the relative productivity potential of each species, rather than which species currently occupies the site.

High-grading as a cause of uneven-aged stands is not expected to be a problem in the future. Technological changes and greater utilization of the aspen resource encourage the use of all grade and site classes. Similarly, the overmaturity problem will disappear as mature and overmature stands are gradually harvested and renewed or rehabilitated. There are strong economic and silvicultural reasons to rehabilitate the current large areas of decadent stands and bring them back to full production. A task of this magnitude will have to be supported by appropriate management regulations and incentives, which are currently lacking.

MANAGEMENT OF BALSAM POPLAR COMPONENT

In many aspen stands in western Canada, as much as one-third of the basal area identified as aspen is actually balsam poplar (Fig. 5). Due to the low demand, most of the balsam poplar is left standing in aspen cutovers. These residuals have a negative influence on aspen suckering, and also hinder site preparation. This problem will diminish as balsam poplar will be increasingly accepted by the forest industry. For example, two newly announced pulp mills in Alberta will be using both aspen and balsam poplar.

With increased utilization of balsam poplar, several other questions arise about its regeneration silviculture, treatments for its encouragement, and density and stocking requirements for optimal growth. We do not know what growth and yield we can expect in second growth balsam poplar, or in mixed stands of balsam poplar and aspen.

Little is known also about wildlife implications of balsam poplar utilization. As a wildlife browse species, aspen is superior to balsam poplar. For this reason it is important to know if current or future practices of aspen-balsam poplar harvest will lead to a long term increase in balsam poplar. Furthermore, long-lasting balsam poplar residuals provide important habitat for cavity-nesting birds.

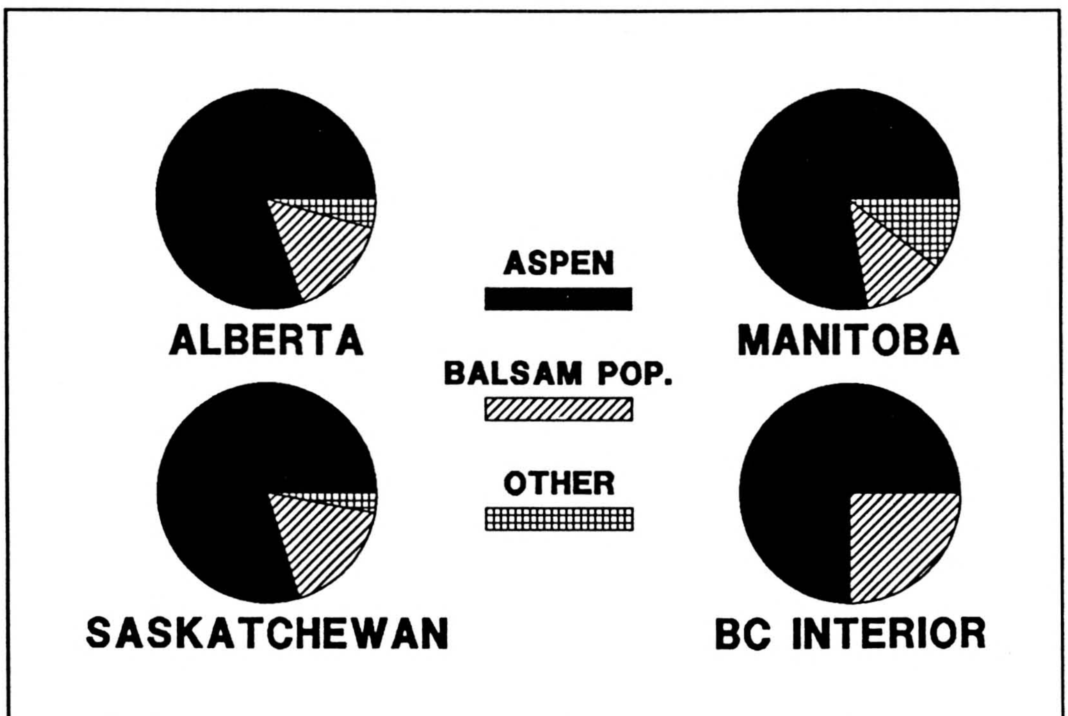

Figure 5.--Species mix in aspen (hardwood) stands in western Canada.

WILDLIFE IMPLICATIONS OF CHANGING HARDWOOD MANAGEMENT

Wildlife concerns on forest land figured prominently in the 1989 survey of Canadian public opinion on forestry issues (Environics Research Group Limited 1989). It showed that 35 percent of the respondents identified environment/wildlife as the greatest concern, 27 percent of those surveyed identified wildlife as the most important use of Canada's forests and logging (timber value) came in fourth. Publicly expressed concerns about the wildlife implications of increased hardwood harvesting in western Canada usually focus on reduction of habitat diversity and a trend towards an increased hardwood component in the mixedwood region.

D.A. Westworth and Associates Ltd. (1984) examined the potential effects of short-rotation harvesting of boreal aspen stands on wildlife in Alberta. The study involved a comparative evaluation of habitat conditions and wildlife use of aspen stands of different ages; including 1 and 2-year-old clearcuts, and 14-, 30-, 60-, and 80-year-old stands. Overall densities of breeding birds were predicted to increase under short-rotation management, however approximately one-third of the species common to aspen forests would undergo a significant decrease in abundance. The absence of large diameter snags in managed stands would result in a pronounced decrease in abundance of snag- dependent birds. Browse production was highest in the 14-year-old stands, while maximum production of grasses and forbs occurred in the 14- and 30-year- old stands, respectively. As a result, short-rotation harvesting would be beneficial to ungulates as long as management programs include silvicultural options designed to meet the cover requirements of each species. Among the furbearing mammals, snowshoe hares, beaver, lynx, coyotes and wolves would likely benefit while species such as marten, fisher and red squirrel would be adversely affected by a reduction of mixedwood or coniferous forest under short-rotation management.

Sizes and patterns of cutovers have long been of concern to wildlife officials. In Saskatchewan, softwood clear-cut areas are currently limited to 40 ha and hardwood clearcuts range from 120 to 400 ha (Little 1988). In their suggested methods for reclamation of moose habitat in the prairie provinces, Green and Salter (1987) recommended the maintenance of dense forest blocks at least 1 ha in size to provide escape and thermal cover within clearcut areas. Recommendations on size and distribution of habitat units are provided by Green and Salter (1987) for all of the large mammals that inhabit mixedwood and aspen parkland areas in Alberta, as well as for spruce grouse, and sharp- tailed grouse.

PUBLIC CONCERNS ABOUT CHANGING HARDWOOD MANAGEMENT

The 1989 National Survey of Canadian Public Opinion on Forestry Issues (Environics Research Group Limited 1989), commissioned by Forestry Canada, confirmed that a substantial majority of the 2,500 Canadians polled are concerned about forest management in Canada. In western Canada, that anxiety impinges directly on use and management of the aspen resource, judging from the concerns most commonly voiced: dislike for large clear-cut areas; doubts about the effectiveness of forest renewal programs; and fears that future forests will resemble agricultural monocultures. In the prairie provinces, 69 percent of respondents disapproved clear cutting as a logging method. Because there is so little history of hardwood harvesting in western Canada, these concerns are presumably based on public perceptions of coniferous harvesting. The public does not understand that clear cutting is the only effective way to achieve aspen regeneration. Where this is understood, the issue generally centers on the size of clear cuts and disruption of wildlife habitat.

The Canadian public is familiar with nursery production of seedlings and with planting because this method of coniferous forest renewal has been well publicized in recent years. The effectiveness of root sucker regeneration in aspen is not as well known to the public. Foresters are being asked why nurseries are not now gearing up for production of deciduous planting stock, in view of the large amount of hardwood harvesting on the horizon. This question suggests that there is a need for public information programs and demonstration areas to publicize that aspen sucker regeneration makes nursery production and subsequent planting of seedlings unnecessary.

ASPEN MANAGEMENT IN WESTERN CANADA IN THE FUTURE

ASPEN RESOURCE AND INDUSTRIAL DEVELOPMENTS

The aspen resource in western Canada has been called a "huge and hidden resource." Over the past 20 years several meetings and symposia were held with the objective to promote aspen utilization in the region. These did not result in a significant upsurge in aspen use until recently, when technological improvements (e.g., in OSB, CTMP manufacture) together with increased demand for forest products and economic strength in the forestry sector resulted in major breakthroughs in aspen utilization. As one Alberta government manager implied, the current expansion of the industry and the dramatic increase in hardwood use in Alberta resulted from favorable economic circumstances as well as from aggressive industry development and promotion programs guided by the provincial government (Brennan 1988).

Alberta has been the major focus for forestry developments in Canada and the province is experiencing a total of 3.4 billion in new capital investments. Expanded pulp production for 1988 to 1991, and the list of new and announced pulp mills illustrates this point (Table 1). Most of these new developments will use aspen, some up to 80 percent of the total consumption.

Aspen consumption planned for the new mills represent a giant step in aspen use in western Canada. The wide gap between aspen AAC and harvest that existed even 2 - 3 years ago is narrowing very quickly in some areas (Fig. 6), especially when one considers economically accessible timber. The increasing trend in aspen utilization will likely continue, with occasional declines related to market conditions, alternate land use demands, and environmental considerations.

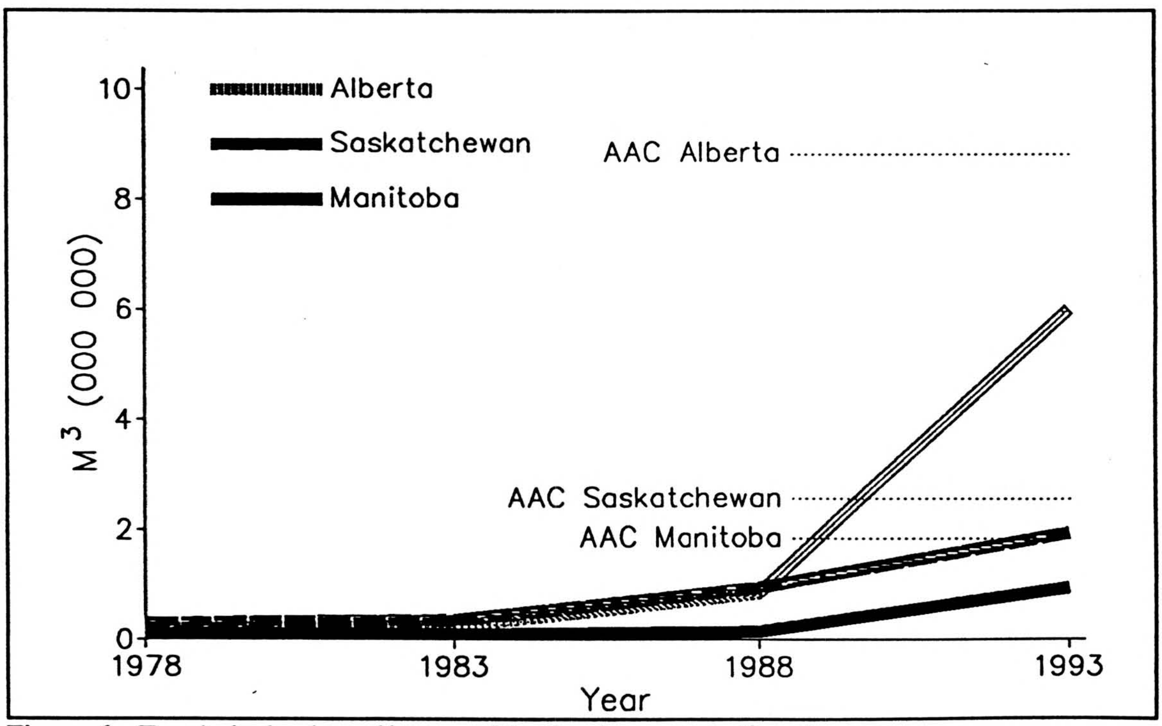

Figure 6.--Trends in hardwood/aspen utilization in western Canada.

Table 1.-- New and proposed aspen pulp and paper mills in Alberta.

Company	Location	Process	Start of Operations	Utilization Aspen (million m³)	Utilization Softwood (million m³)
Millar Western Industries Ltd.	Whitecourt	CTMP	1988	0.31	0.30
Daishowa Canada Co. Ltd.	Peace River	BKP	1990	1.19	0.63
Alberta Energy Co. Ltd.	Slave Lake	CTMP	1991	0.26	0.05
Alberta-Pacific Forest Industries Inc.	Athabasca	BKP	1991	1.80[1]	0.36
Procter and Gamble Cellulose Ltd. (Expansion)	Grande Prairie	BKP	1992	0.69	0.69
Alberta Newsprint Company Ltd.	Whitecourt	Newsprint Mill	1990		

[1]Includes balsam poplar.

Source: Alberta Forestry, Lands, and Wildlife; W. Ondro, Forestry Canada

IMPROVEMENTS IN ASPEN REGENERATION AND SILVICULTURE

New approaches to aspen as a commercial crop and longer planning horizons in management and industrial strategies have quickly changed the approach to and appreciation of aspen silviculture and management. A survey on aspen management prospects conducted in the region revealed a strong consensus amongst respondents that aspen regeneration and growth are important concerns today and require appropriate management action. Many respondents are ready to consider intensive silviculture practices to improve the health and productivity of the aspen resource where required. Although aspen regeneration is generally assured after clearcutting of hardwood stands, there are situations where regeneration investments may be needed.

Soil compaction may cause understocking on sensitive sites (moist, heavy soils) and so can shrub and grass competition, which may also hinder the growth of regeneration. Modification of harvesting technologies and careful planning of the season of harvest can provide solutions. In addition, new harvesting technology will need to be developed that will allow aspen removal, while protecting the advanced conifer regeneration in two storey stands.

Although more remote, planting of improved aspen and poplar stock on abandoned farm land near manufacturing facilities by forestry enterprises may become feasible in the future. These would be intensively managed plantations grown in short rotations. While spacing and thinning programs will not increase the production of wood for pulp or OSB, they may be applied in areas where unbalanced age-class distribution requires augmentation of merchantable yield at certain periods.

THE GREENHOUSE EFFECT AND ASPEN MANAGEMENT

Any projections of aspen growth, management, and utilization are based on the premise that the natural environment will remain the same. Should a major change occur in the climate, the conditions for growth and survival will change. Climatologists are concerned that the steady increase of "greenhouse" gases, such as carbon dioxide and methane, in the atmosphere will result in an unprecedented rapid rise in temperature. It is anticipated that the global temperature will rise up to 5°C by 2050, and that the increase will be pronounced in the northern hemisphere (Manabe and Wetherald 1986). Precipitation would remain the same, or increase slightly in the western interior of Canada.

It is expected that this change will be manifested by longer growing seasons and warmer winters, with a slight rise in the summer temperatures. The higher temperatures will induce greater evapotranspiration, resulting in higher water consumption by plants. Moisture deficiency will occur with increased frequency and longer duration, especially in the southern part of the boreal forest. Severe drought and subsequent diseases, such as Hypoxylon and Cytospora cankers, can kill aspen stems while the roots remain alive and sucker growth will follow. However, repeated droughts may exhaust the trees, finally killing them. This would result in a generally northward expansion of the grasslands and aspen parklands, well into the present boreal forest by the mid 21st century.

The effect of the change in the climate would be a northward expansion of the present vegetation zones. Aspen would suffer severely in the south, but would benefit in the north (Fig. 7) from the longer growing season and milder winters. Aspen is expected to flourish in northeastern British Columbia, and in northern Alberta, but the stony, shallow soils of the Canadian Shield will limit its growth in northern Saskatchewan and Manitoba. Aspen may spread to higher elevations in the foothills, where it should do very well.

Changes in aspen growth can be expected at any geographic location. Aspen- using industry, located in the south, may find local supplies dwindling and transportation costs increasing necessitating a move north. Regeneration is likely to fail in climatically stressed areas.

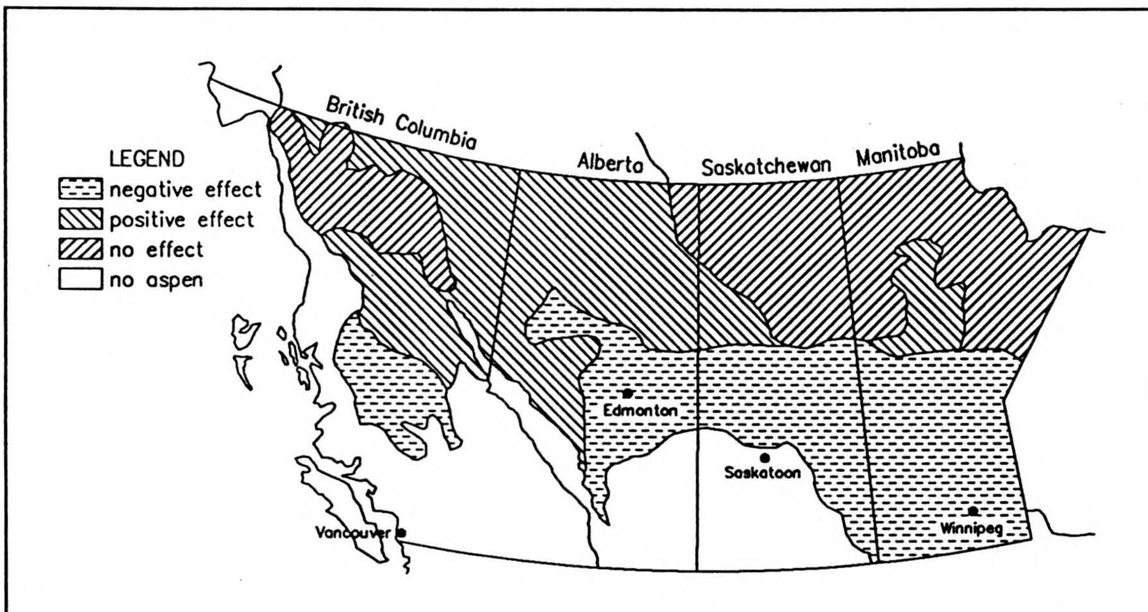

Figure 7.--Anticipated effects of 2 x CO_2 warming on aspen. Some areas are mapped as "no effect" because of unfavorable edaphic or physiographic conditions. (Provided by S. Z. Zoltai, Forestry Canada, Edmonton).

FUTURE ASPEN RESOURCE

One may wonder whether the current upsurge in aspen utilization might run out of steam, or simply run out of aspen, as we have run out of eastern white pine and are close to running out of white spruce. Although it is possible to degrade the aspen resource, e.g., by reducing genetic diversity, it is unlikely that this resource in western Canada could disappear even after several rotations. Aspen is a permanent member of the Boreal Forest community, and neither fire nor logging can eliminate it. Its vigorous suckering and seeding ability ensures its continued presence and growth in this region. Aspen is a resilient species that occupies a broad range of sites (Corns 1988). This ecological resiliency bodes well for aspen. Not only will aspen persist, but further increases in aspen AAC can be expected, or enhanced when needed, from several sources. Aspen harvesting is now concentrated in stands of old age classes. A shift to younger stands will result in shorter rotations, which will also mean a simultaneous reduction in cull and more complete utilization.

A good portion of the aspen growing stock is in agriculture fringe areas, dispersed among many small holdings. Demand for aspen wood will open a significant supply source from those "woodlots", and thus widely benefit the local economy. At least one of the newly announced forestry developments in Alberta will procure a significant portion of its aspen log supply from private woodlots. Additional fibre sources will be generated from closer utilization of aspen wood by satellite chipping, whole tree harvesting, and technological improvements in pulping and OSB manufacturing.

A significant increase in the hardwood growing stock is occurring over extensive areas of the Boreal Mixedwood section because of the steadily increasing aspen component in mixedwood and conifer cover types. In the long run, this will mean a significant shift of the conifer land base towards hardwoods, although appropriate management policies are not yet in place to reflect this situation. So reassessment and realignment of forest management strategies are urgently needed.

Commercial interest in aspen is expected to be as enduring as the species itself. Aspen's prime use - pulp and panelboard - are likely to endure in world markets. Aspen has also been described as the "true champion" of multiple use (Thorp 1988) and is also highly regarded in terms of aesthetics and public perceptions.

Aspen utilization has made a giant step in the west. The work has just begun. It is now up to researchers, policy makers and forest practitioners, to respond to this momentum and develop sound forest management and renewal strategies to sustain our aspen forest.

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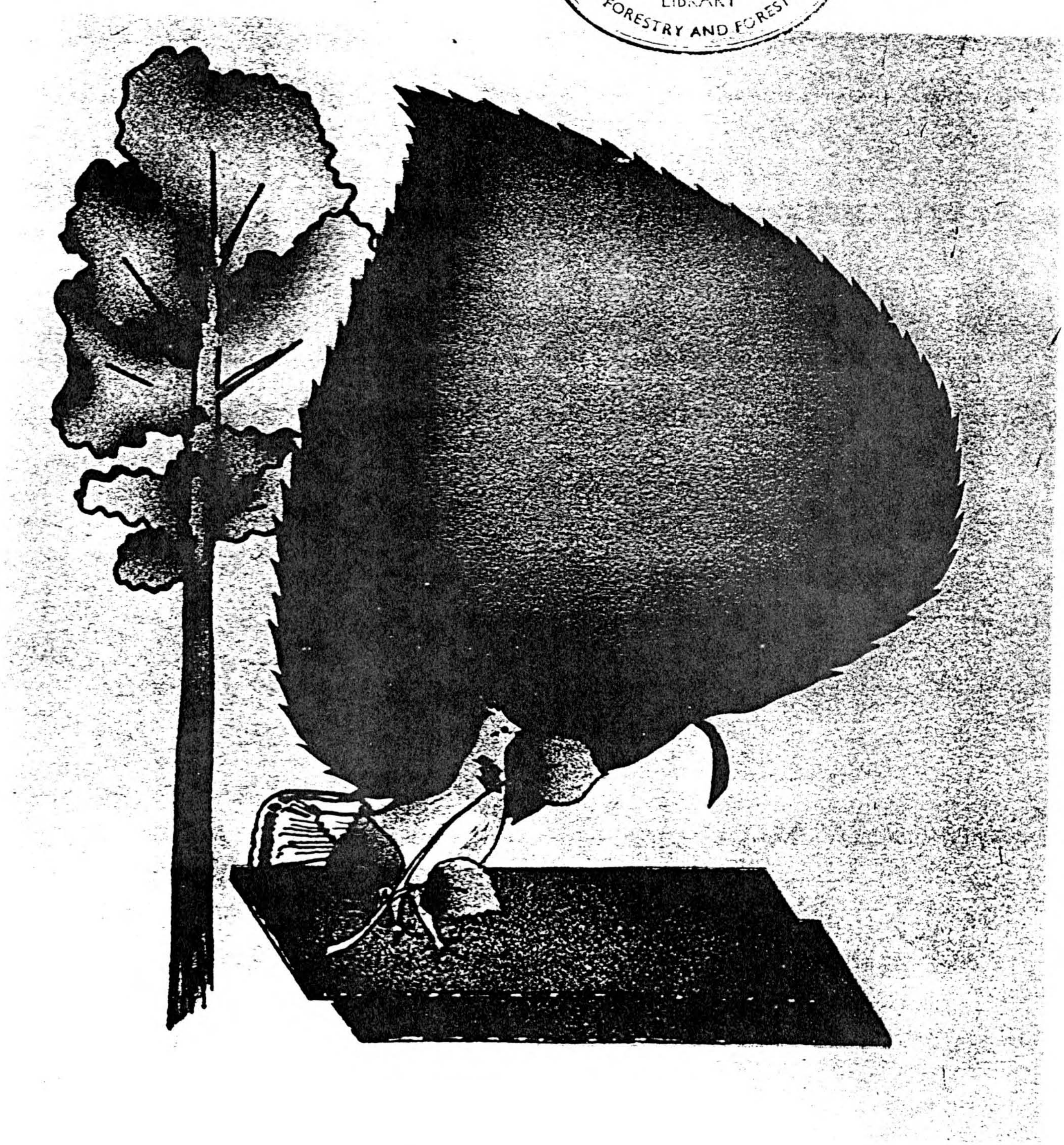
General Technical Report NC-140

Aspen Symposium '89

Proceedings



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This proceedings of Aspen Symposium '89 contains 31 papers balanced between the subjects of aspen ecology and silvics, aspen management and silviculture, and aspen products and utilization. It also includes eight brief papers based on poster presentations.

KEY WORDS: Aspen, ecology, management, utilization.