A semi-natural approach to mixedwood management in the prairie provinces

by V.J. Lieffers and J.A. Beck Jr.

The white spruce-aspen mixedwood associations of the prairie provinces have a variety of possible compositions ranging from pure aspen to pure white spruce to mixtures of the two. Regulations and silvicultural treatments have been largely aimed at promoting the more commercially valuable white spruce, largely through plantation establishment and management. We feel that it is time to re-evaluate our current management of these mixedwoods for the following reasons: 1) Because of competition from hardwoods and grass, white spruce regeneration has been very expensive and only partly successful. 2) Hardwoods are now acceptable crop trees; the traditional conifer bias is now inappropriate and there are increasing possibilities for conflict between hardwood and softwood users of the same land base. 3) The increased understanding of forest ecosystems and a strong environmental movement have resulted in demands for management systems that are ecologically based.

In future, management systems will likely move away from expensive single species plantation systems and promote more mixed forests. To retain the white spruce component of these forests, systems must be developed that enhance natural regeneration of lower densities of white spruce over a wider area. These must be coupled with refined harvesting techniques that protect spruce regeneration during the harvest of the aspen. Growth and yield models must accurately reflect the ecology of mixedwoods. Tenure systems should be structured to ensure that one manager has responsibility for silviculture prescription and harvest scheduling of a given area. The same manager, however, must ensure maintenance of the allowable cuts of each species and the biodiversity of the area.

Key words: mixedwoods, silviculture, white spruce, aspen, biodiversity, ecosystem management.

Les peuplements mélangés composés d'épinette blanche et de tremble que l'on retrouve dans les provinces des Prairies peuvent se présenter sous diverses compositions allant de la tremblante pure à la pessière blanche pure tout en passant par un mélange des deux. Les normes et les traitements sylvicoles visaient essentiellement à promouvoir la plus grande valeur commerciale de l'épinette blanche, principalement par voie de création de plantation et d'aménagement. Nous croyons qu'il est temps de réévaluer l'aménagement actuel de ces peuplements mélangés pour les raisons suivantes: 1) Parce que la lutte contre la compétition exercée par les feuillus et les graminées au niveau de la régénération de l'épinette blanche s'est avérée dispendieuse et partiellement réussie. 2) Les feuillus sont maintenant des espèces acceptables au niveau de la récolte; le biais traditionnel envers les conifères est actuellement inapproprié et les possibilités de conflits entre les utilisateurs de feuillus et de résineux sur un même territoire sont de plus en plus fortes. 3) La compréhension sans cesse plus poussée des écosystèmes forestiers ainsi que les mouvements écologiques plus que présents ont entraîné des demandes pour des systèmes d'aménagement qui reposent plus sur l'écologie. Dans l'avenir, les systèmes d'aménagement devront vraisemblablement s'éloigner des systèmes onéreux de plantation contenant une seule espèce et faire une plus grande promotion des peuplements mélangés. Afin de conserver la portion d'épinette blanche présente dans ces peuplements, des systèmes doivent être élaborés pour accroître la régénération naturelle des épinettes blanches en moins grandes densités sur de plus grandes superficies. Parallèlement, des techniques de récolte plus soucieuses de la protection de la régénération en épinette au cours de la récolte du tremble doivent être mises en opération. Les modèles de croissance et de rendement doivent refléter avec précision l'écologie des peuplements mélangés. Les systèmes de tenures devraient être structurés pour s'assurer qu'un gestionnaire est responsable de la prescription sylvicole et du calendrier des récoltes pour un territoire donné. Le même gestionnaire, cependant, doit s'assurer de maintenir les coupes à des niveaux permis pour chacune des espèces, ainsi que la biodiversité du territoire.

Mots clés: peuplements mélangés, sylviculture, épinette blanche, tremble, biodiversité, aménagement des écosystèmes.

Introduction

Mixed species stands can be some of the most challenging types of forests to manage (Smith 1986). Managers must consider species with different silvicultural requirements, and different economic values and project the growth and allowable cuts for each species. Mixedwoods of the boreal forests of the prairie provinces are typical examples of such forests. This is an appropriate time to re-evaluate the management of these mixedwoods for these reasons: 1) We have had a number of decades of inconsistent or poor regeneration of white spruce in these stands (Navratil *et al.* 1991). 2) With recent mill developments in Alberta, Saskatchewan and Manitoba, most

of the annual allowable cut of conifer, and in some areas much of the aspen resource is allocated. This results in less flexibility and more pressure on the resource to sustain these industries. 3) Better understanding of forest ecosystems and an active environmental movement have resulted in demands for better management of ecosystems. In this paper we examine past practices in mixedwood management and silviculture, current issues and future directions. This paper is partly based upon surveys and discussions with silviculture foresters from industry and government in the three prairie provinces.

Ecology

The mixedwoods of the boreal forests of the prairie provinces are dominated by trembling aspen and white spruce (Rowe 1972) but may also contain balsam poplar, paper birch, black spruce, balsam fir and pines. Mixedwood forests are usually found on mesic sites and are particularly abundant in the Mixedwood sec-

Department of Forest Science, University of Alberta, Edmonton, Alberta, Canada T6G 2H1.

Paper presented at the Silviculture Conference, Toronto, Ontario, September 1993.

tion of the boreal forest (Kabzems *et al.* 1986) but significant mixed stands of aspen and white spruce are also found in the Manitoba Lowland, Northern Coniferous, Upper Churchill, Hay River and Lower Foothills sections of the boreal forest (Rowe 1972). Most natural stands originated after fire. The associations that make up mixedwoods have at least three distinct compositions; depending upon the stage of development, stands can be dominated by either white spruce or aspen or a mixture of the two (Corns and Annas 1986). The type of stand of a given association is as much a product of successional stage and stand history (McCune and Allen 1985) as it is of site type. After disturbance, aspen regrowth is rapid due to extensive suckering from roots. Depending upon seed sources and seedbed conditions, recruitment of white spruce may be relatively soon after disturbance or the spruce may slowly establish over many decades (DeLong 1991). In contrast to the short-lived aspen, white spruce has relatively slow juvenile growth rates and usually does not become a dominant in the canopy until later in succession. Mixedwood sites are usually moderate to rich in nutrients. This results in diverse and vigorous shrub and herb communities in early successional stages.

History of Management

In the first half of the century most of the harvesting in mixedwoods was restricted to extraction of spruce sawlogs on sites with good access. This was usually associated with diameter limit cutting, i.e. harvest restricted to trees above a minimum diameter. Gradually, clearcutting and treatments to promote both natural and planted white spruce stock were adopted. In recent years, with the development of oriented strand board and improvements in pulping technology there has been an increased harvest of hardwoods.

Current Silviculture systems

Throughout most of the area, clearcutting is the usual method of harvest. If aspen is the dominant species to be regenerated, there is little treatment of the site, however, slash piles, compacted soils, and damage to aspen root systems are minimized to maintain sucker regeneration of the aspen (Peterson and Peterson 1992). In the coniferous harvest, where aspen is not harvested it is usually left standing to reduce aspen suckering and for the benefit of wildlife. Regeneration of white spruce is more difficult. In general, plantation techniques are used. Clearcut harvesting is usually followed by mechanical site preparation. Depending upon site conditions disc trenching, double discing, blading, ripper or Martini ploughing, Bracke spot scarification, high speed mixing or spot mounding are used. In recent years, on sites with potential vegetation problems arising from seed sources, site preparation has been avoided. Most sites are planted with white spruce seedlings. In recent years large container or transplant stock has been preferred. In the early years following clearcutting, site preparation and planting there is rapid development of shade intolerant species such as aspen, *Calamagrostis canadensis* (Liefers *et al.* 1993) green alder and others which suppress and frequently cause the death of white spruce seedlings. Manual cleaning operations are used on a limited basis in both Alberta and Saskatchewan. Herbicides are applied as a release treatment in Manitoba. In Alberta, where understories of white spruce are identified on inventories, precautions are taken during logging to protect these trees. This is also being tried to a limited extent in Saskatchewan and Manitoba.

Regeneration Standards

For Alberta, regeneration standards were revised in 1991 (Anonymous 1992). They can be summarized as follows. By year eight after harvest, sites which are designated as coniferous must have 80% stocking of milli-hectare plots with an acceptable coniferous seedling that is above a given height (for spruce, 50 cm). Free-to-grow status of these trees must be reached by year 14. Sites designated as mixedwood must achieve the same growth and free to grow standards but the proportion of the stocked plots with acceptable conifer seedlings is reduced from that of the coniferous sites. For hardwood sites, surveys must be completed by year five and a plot is stocked if there are three or more hardwoods of greater than 150 cm. For Saskatchewan, Forest Management Lease Agreement areas require 65% stocking of milli-hectare plots. The operator gets to pick the areas where they will regenerate a particular species. In Manitoba, coniferous sites are surveyed 7 years after harvest and sites must have 75% stocking of milli-hectare plots.

Current allowable cuts are in part based on assumptions about how regenerated stands will perform. Managers in all provinces are concerned about meeting the regeneration standards, and if these are achieved, will the future yields be of the size assumed in the allowable cut calculations. This is of particular concern regarding white spruce yields.

Agents for Change

1. *Conflicting silvicultural objectives*

In Alberta, 62% of the hardwood allowable cut is being harvested while these values are < 50% in Saskatchewan and < 10% in Manitoba. In Alberta and Saskatchewan, however, many forest management units have near 100% allocation of the hardwood allowable cut. In areas where both hardwood and softwoods are committed, often to different forestry companies working on the same landbase, there are problems defining silvicultural objectives. Since aspen matures earlier than white spruce, timing of harvest is a problem. Either the aspen is harvested late in the rotation or the spruce early, if normal clearcutting is applied. Understory protection programs (Brace and Bella 1988) have been developed to protect the immature spruce during the harvest of the mature aspen. These have been applied widely in Alberta and to a limited extent in Saskatchewan and Manitoba. With overlapping tenures this can result in the awkward situation where a deciduous operator is expected to incur greater costs protecting white spruce understory which will be available only to the coniferous operator in the future. There are also conflicts regarding regeneration. For white spruce establishment in mixedwoods, mechanical site preparation is applied partly to reduce the occurrence of aspen in mixedwoods sites yet this treatment is reported to promote stem rots in aspen suckers (Basham 1988). Thus site preparation, applied to mixedwood stands may be inappropriate where both white spruce and aspen are expected to contribute to the productive forest. In addition other activities such as stand tending, road building and maintenance, and protecting non-timber values are more complex with mixed tenures.

2. *Conflicting product goals*

Allowable cuts for much of the prairie provinces have been set with rotations appropriate for pulpwood utilization. This means we will harvest the existing forest at a rate so that regenerated stands will only be of pulpwood size when we need to harvest

them. Thus, 60 to 80 years from now, there will be primarily only pulpwood-sized timber for use. This will result in shortages of sawlogs and the larger trees needed to maintain habitat and biodiversity values.

3. *Regeneration success*

Following clearcutting, there are many examples of poor establishment and performance of white spruce plantations (Drew 1988, Navratil *et al.* 1991). Competition from shade intolerant grasses and aspen has resulted in slow growth and mortality of many white spruce plantations in all three provinces. In our discussions with foresters, establishment of white spruce was considered to be the most serious silvicultural problem in these mixedwoods.

4. *Cost of plantation establishment*

The high costs of mechanical site preparation, planting stock, planting and stand tending (> \$2000 per ha (Navratil *et al.* 1991) lead one to question the wisdom of intensive plantation establishment techniques in relatively low productivity sites (Benson 1988, Pearce 1991). The use of herbicides may reduce the tending costs but these have not been used operationally in Saskatchewan and Alberta for more than 6 years.

5. *Free-to-grow standards*

New performance standards have been legislated for Alberta and are being considered for Manitoba. In Alberta, this demands that at year 14 after harvest, a coniferous crop tree must meet a height requirement and not have a hardwood tree that is 66% of the height of the conifer tree within 1 m (Anonymous 1992). These standards force managers in the direction of plantations and intensive silviculture, i.e. mechanical site preparation, planting large stock, followed by one or more weeding treatments to promote a relatively pure stand. These standards aim to avoid the earlier stages of mixedwood succession.

6. *Environmental concerns*

In recent years the environmental movement has become critical of forest management in the prairie provinces. Areas of criticism, focus on: a) *Clearcut harvesting* – most of the criticism relates to the image of large areas with the large trees gone and the soil torn up. There are, however, more sophisticated concerns related to impacts of clearcutting on nutrient cycling, watershed hydrology, genetic diversity and wildlife populations. Recent concerns relate to forest fragmentation (Schmiegelow and Hannon 1994), biodiversity (Burton *et al.* 1992) and uniformity of cutover size associated with the ground rules for cutting in each province (B. Stelfox pers. comm.). b) *Mechanical site preparation* – the appearance of and possible soil damage associated with heavy mechanical site preparation (D. McNabb pers. comm.) is causing concern. c) *Plantation silviculture* – the image of monocultures and very uniform plantations is a serious concern. Currently, most plantations do come back as mixed stands, but if plantation establishment and vegetation control objectives were completely effective, monocultures and uniformity of stands would result. d) *Herbicides* – chemicals have been distrusted for the past three decades ever since the publication of “Silent Spring” (Carson 1962). There is concern for both human and ecosystem toxicity effects and loss of biodiversity.

Semi-natural Mixedwood Management

Abandon Management for Single Species

The regulations and silvicultural systems that force relatively pure white spruce stands on mixedwood areas are not appropriate. This “conifer bias” and plantation system has led to the large investments in site preparation, planting and tending stands necessary to achieve this feat. It has also resulted in demands for herbicides to control competing vegetation to protect this large investment. These management systems and regulations, although well intentioned, are probably inappropriate given our understanding of the ecology of mixedwood sites, the recent increase in value of aspen fibre and relatively poor economics of white spruce plantations. Not surprisingly, hardwood operators are also developing a “hardwood bias” on lands designated for hardwoods; here there is no attempt to encourage white spruce even though sites are capable of growing spruce. Clearly we should recognize that mixedwood ecosystems grow mixtures of species and our management and silvicultural systems should reflect this fact. Indeed, in natural stands, mixtures of white spruce and aspen are more productive than either species by itself (Anon. 1985).

Ecosystem Management

We foresee continued pressure for more ecologically based management of mixedwood forests in the future (Rowe 1992, Martin *et al.* 1992). Society will demand that most working forests on public lands be held in a semi-natural state (Rowe 1992) and that biodiversity be considered at both the stand and landscape level (Burton *et al.* 1992). Very likely with the range of demands for species and habitat diversity, there will not be a single “correct management system” for these forests. There will be demands for large and small cutovers, and a variety of stand compositions but probably more mixed stands. These mixed stands could have a low density of white spruce; but occupy most of the landbase. Such stand types appear to be very valuable from the perspective of biodiversity (B. Stelfox pers. comm.). We also expect to see a wide range of stand ages in the landscape. The harvest of old-growth conifer and conifer dominated mixedwood stands as a first priority has resulted in a reduction of this older forest type and large conifer trees in the landscape. Perhaps longer rotation lengths for some stands or the use of partial-cut silviculture will maintain the old-growth character in the landscape. These old-growth features cannot be ignored; if the trend for younger forests is maintained, there will be more demands for landbase deletions (protected areas).

Given the above management objectives we expect a much larger percentage of the white spruce to be regenerated using various forms of partial cut silviculture. The understory protection system which retains existing stands of white spruce during the harvesting of aspen (Brace and Bella 1988) is the simplest system and it has been adopted in Alberta and considered elsewhere. The next logical development is the active encouragement of white spruce in the understory. This might be achieved by underplanting or management of seed sources and seedbeds in the understory of aspen or through shelterwood, group selection or selection systems in spruce dominated stands. We expect these systems to be “cost competitive” compared to typical clearcutting followed by planting and tending. While harvesting and roading costs in a partial cut system will undoubtedly be higher than with clearcutting, these should be outweighed by other gains: 1) The cost of regener-

ation of the white spruce should be lower as vegetation competition is suppressed by shade (Liefvers and Stadt 1994). 2) The natural long delay in development of white spruce growing stock in mixedwoods should be drastically reduced if seedlings can be developed in the understory of a previous stand. 3) The final logs produced from a partial cut system are likely to be larger and thus more valuable than from clearcut systems. 4) The aesthetic appeal and biodiversity/wildlife benefits for some species will be increased by development of multi-aged mixedwood stands. Clearly there are some information impediments that must be overcome before this type of management can be adopted. The most notable is the need to reduce possibilities of blowdown in partial cut areas.

Annual Allowable Cut

The current inventories divide the mixedwood complex into four groups: pure coniferous, pure deciduous or deciduous-or coniferous-dominated mixedwoods. Given this breakdown, modellers have sampled by age and site class to develop separate volume functions where volume is a function of age and site. This division, however, does not recognize the natural succession of these stands as young deciduous stands may eventually develop into mixed or pure coniferous stands. Conversely, virtually pure conifers stands may naturally revert to nearly pure hardwoods after disturbance. In order to set regeneration standards and allowable cuts which will maintain the conifer and hardwood production from the mixedwood complex, there is a need for a reliable mixedwood growth model that recognizes different stand compositions and the natural succession in this forest complex.

If we adopt partial cut silvicultural systems and more natural regeneration, stand modellers will be challenged even further. Ingress of white spruce over time will be very difficult to model given the uncertainties of white spruce seed sources and our poor understanding of the appropriate microsites for seedlings in understory environments. Secondly, growth of white spruce in understories or following release cuttings is not well studied but this information will be needed to justify partial cut silvicultural systems. Clearly, the above mixedwood model must also predict recruitment and growth of the various species over succession or following silvicultural treatments.

Allowable cuts will have to be set such that a significant part of the spruce harvest from the mixedwood complex is larger (older) than current assumptions used. Current rotations, as short as 80 years will not realistically produce the large spruce trees needed to sustain a sawlog industry or biodiversity. The semi-natural/partial cut option suggested here provides a means to produce large spruce while producing earlier crops of hardwoods.

Land Tenure Systems

Unless goals and regulations are harmonized, we foresee conflicts between hardwood and deciduous operators on the same landbase (Benson 1991). There will be considerable need for regulatory intervention by governments if joint tenure is maintained. Alternatively, we think the best solution is a tenure system where one managing authority has the responsibility for silvicultural prescriptions and harvesting for a given area. The same manager should ensure maintenance of allowable cuts of each species and the biodiversity of the area. The Forest Management Licence system in Manitoba uses such a system. Governments must set goals/objectives regarding the propor-

tions of the landbase or inventory to be maintained in coniferous and deciduous production. We suggest that despite the difficulties of spruce establishment, the coniferous component of mixedwoods must be maintained. The white spruce is too valuable as a fiber source and for habitat diversity to be reduced in future forests. Once inventory goals are set, the land manager can develop appropriate management and silvicultural prescriptions to achieve them. The managing group should have the size of the allowable cut and indeed the right to harvest at all linked to their performance at maintaining the inventory goals. Lacking these goals, managers will always question the increased costs of regenerating the spruce component of these forests. Most of the time, the high costs necessary to achieve spruce regeneration will be justified based upon the desire to maintain the inventory goals and the allowable cut of conifer.

Acknowledgments

We thank K. Branter, P. Wearmouth, B. Macmillan, J. Lane, K. Gorham, J. Benson, M. Adamson, L. Yarn, R. Lamont, D. Neufeld and V. Keenan for discussions and suggestions for this paper.

References

- Anonymous 1985.** Alberta phase 3 forest inventory: yield tables for unmanaged stands. Alberta Energy and Natural Resources, ENR Rep. 60a.
- Anonymous. 1992.** Alberta regeneration survey manual. Alberta Environmental Protection. Edmonton. Pub. No. 70.
- Basham, J.T. 1988.** Decay and stain 10 years later in aspen suckers subjected to scarification at age 3. *Can. J. For. Res.* 18: 1507-1521.
- Benson, C.A. 1988.** A need for extensive forest management. *For. Chron.* 64: 421-430.
- Benson, J.A. 1991.** Mixedwood forests: some policy issues of the '80s and beyond. pages 26-29 *In* A. Shortreid, Editor. Northern mixedwood '89. Proc. Symp., Sept. 12-14, 1989. Fort St. John, B.C. Pacific Forestry Centre. Victoria, B.C. FRDA Rep. 164.
- Brace L. and I.E. Bella. 1988.** Understanding the understory: dilemma and opportunity. *In* Management and utilization of northern mixedwoods. J.K. Samoil, Ed. Can. For. Serv. Info. Rep. NOR-X-296. pp. 69-86.
- Burton, P.J., A.C. Balisky, L.P. Coward, S.G. Cumming and D.D. Kneeshaw. 1992.** The value of managing for biodiversity. *For. Chron.* 68: 225-237.
- Carson, R. 1962.** Silent spring. Houghton Mifflin Co. New York.
- Corns, I.G.W. and R.M. Annas. 1986.** Field guide to forest ecosystems of west-central Alberta. Northern Forestry Centre. Forestry Canada. Edmonton.
- DeLong, C. 1991.** Dynamics of boreal mixedwood ecosystems. pages 30-31 *In* A. Shortreid, Editor. Northern mixedwood '89. Proc. Symp., Sept. 12-14, 1989. Fort St. John, B.C. Pacific Forestry Centre. Victoria, B.C. FRDA Rep. 164.
- Drew, T.J. 1988.** Managing white spruce in Alberta's mixedwood forest: the dilemma. *In* Management and utilization of northern mixedwoods. J.K. Samoil, Ed. Can. For. Serv. Info. Rep. NOR-X-296. pp. 35-40.
- Kabzems, A., A.L. Kosowan and W.C. Harris. 1986.** Mixedwood Section in an ecological perspective. Saskatchewan Tech. Bull. No. 8. 2nd Ed. Canada-Saskatchewan FRDA. Sask. Parks and Renewable Resources.
- Liefvers, V.J. and K. Stadt. 1994.** Growth of understory *Picea glauca*, *Calamagrostis canadensis* and *Epilobium angustifolium* in relation to overstory light. *Can. J. For. Res.* (in press).
- Liefvers, V.J., S.E. Macdonald and E.H. Hogg. 1993.** Ecology of and control strategies for *Calamagrostis canadensis* in boreal forest sites. *Can. J. For. Res.* 23: 2070-2077.

Pearce, C.V. 1991. Some thoughts on the economics of mixed-wood management. pages 65-72. *In* A. Shorttreid, Editor. Northern mixed-wood '89. Proc. Symp., Sept. 12-14, 1989. Fort St. John, B.C. Pacific

Schmiegelow, F.K.A. and S.J. Hannon. 1994. Adaptive management, adaptive science and the effects of forest fragmentation on boreal birds in northern Alberta. *Trans. N. Amer. Wildl. Conf.* No. 58. in press.

Smith, D.M. 1986. The practice of silviculture. Wiley, New York.