From: Forest Regeneration at High Latitudes--The Proceedings of an International Workshop. U.S.D.A. For. Serv., Pac. Northwest For. Range Exp. Stn., Gen. Tech. Rep. PNW-107 (1980).

SOME PRACTICAL METHODS FOR SECURING ADEQUATE POSTCUT FOREST REPRODUCTION IN CANADA

Z. Chrosciewicz

Research Scientist, Northern Forest Research Centre

Canadian Forestry Service, Department of the Environment

Edmonton, Alberta, Canada

THE FOREST RESOURCE

Canada's forest land occupies an area of 3,417,000 km^2 (1,319,300 mi^2), which is about 37% of the nation's total land area (9,218,000 km^2 [3,559,000 mi^2]), nearly 4.7 times the area of agricultural land (730,000 km^2 [281,800 mi^2]), and second only to the combined area of tundra, barrens, alpines, and other similar wildlands (4,334,000 km^2 [1,673,400 mi^2]). About 3,141,000 km^2 (1,212,700 mi^2) of the forest land are classified as an unreserved production land that can be used for growing timber. However, only 1,984,000 km^2 (766,000 mi^2) of the production land are inventoried as currently productive forest land, of which 1,611,000 km^2 (622,000 mi^2) are economically accessible (Bowen 1978).

The wood volume of the productive and economically accessible forest land is estimated at 17,229,000,000 m^3 (60,835,599,000 ft^3) (Bowen 1978). About 80% of this wood volume is in softwoods, with the most abundant species being black spruce (*Picea mariana* [Mill.] BSP.), white spruce (*Picea glauca* [Moench] Voss), jack pine (*Pinus banksiana* Lamb.), lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), balsam fir (*Abies balsamea* [L.] Mill.), eastern hemlock (*Tsuga canadensis* [L.] Carr.), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), eastern white cedar (*Thuja occidentalis* L.), western red cedar (*Thuja plicata* Donn), and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco). The remaining 20% of the wood volume is in hardwoods, with poplar species (*Populus tremuloides* Michx. plus some *Populus balsamifera* L.) and white birch (*Betula papyrifera* Marsh.) predominating (Cayford and Bickerstaff 1968; Bowen 1978).

As calculated for the area south of 60° N latitude, where in fact most of Canada's forests are located, the annual allowable cut and the average annual timber harvest are 256,305,000 m^3 (9,050,129,600 ft^3) and 156,383,000 m^3 (5,521, 883,700 ft^3), respectively, leaving some 99,922,000 m^3 (3,529,245,800 ft^3) in reserve. The implied availability of this reserve, however, is somewhat deceiving because about 43% of the wood volume that remains uncut is economically inaccessible. Moreover, timber deficits begin to occur at a more localized level, and softwood supply problems are on the increase (Reed et al. 1978a; Newnham 1978).

THE STATE OF FOREST REGENERATION

Although Canada is still one of the world's leading forest nations, there is an increasing general apprehension that this favorable position may be lost in the not-too-distant future unless substantial improvements are made right now in the overall reforestation of problem cutovers and other fail areas. The backlog of such areas, variously estimated in excess of 44,515 km^2 (17,190 mi^2), is increasing at an average annual rate of about 2,728 km^2 (1,053 mi^2). Roughly 56% of this increase is attributable to regeneration deficiency after harvest cutting, and a further 44% is attributable to other causes such as insect and disease infestations or the occurrence of certain types of wildfire. It is estimated roughly that about 20% of the total annual harvest area fails to regenerate adequately to the desired tree species, while the remaining 80% of such area regenerates at an acceptable level either by unaided means such as natural seeding, resprouting, etc., or through the use of mechanical scarification, controlled burning, planting, direct seeding, etc. in various combinations (Paille 1977).

Most of the productive forest land in Canada is under provincial jurisdiction (87%) (Bowen 1978), and practically all primary wood-processing industries within such lands operate on the basis of long-term leases. This arrangement is often severely criticized because it seldom results in the practice of proper land management, including the very fundamental task of forest regeneration. Some provincial forest services are doing better jobs of managing their lands than are the others, but still there is not even one provincial organization that can claim consistently adequate forest regeneration following any kind of disturbance, and this includes harvest cutting (Reed et al. 1978a; Newnham 1978). As for the federally (6%) and the privately (8%) owned productive forest land (Bowen 1978), the overall managerial performance in both these cases is not better than that on the provincial land. In only one or two instances, the privately owned land appears to be managed at an acceptable level. However, the provinces, the private sector, and the federal government departments now are beginning to recognize the urgent need for more intensive management, including work on forest regeneration (Reed et al. 1978a, 1978b; Newnham 1978). Let us hope that the participants involved will agree soon on the proper funding necessary for effective implementation of the intended

MAJOR CAUSES OF REGENERATION FAILURE

Many softwood species fail to regenerate adequately after harvest cutting mainly because most of the loose, surface forest-floor materials remain undisturbed. The surface materials, consisting often of feather moss (*Pleurozium schreberi* [Brid.] Mitt. occasionally with some *Hylocomium splendens* [Hedw.] B.S.G. and *Ptilium crista-castrensis* [Hedw.] De Not.) and foliar litter that merge downward into either an upland mor or a lowland peat, are subject to rapid losses of moisture when exposed to increased solar radiation and ventilation. This alone makes them extremely poor media for seed germination and seedling survival. Moreover, the overshading created by logging slash and the often severe competition from deciduous vegetation can further hinder the re-establishment of softwoods after cutting. These conditions can be rectified, however, by either mechanical scarification or controlled burning, with provisions for subsequent planting or seeding.

The regeneration failures may also occur when, in absence of marginal seed sources, wildfires destroy young softwood stands or they burn through softwood clear-cut areas. In both instances, prompt replanting or reseeding is required before plant competition becomes too severe.

Adequate protection from insects, disease, and mammals must be provided under all circumstances to minimize the regeneration losses. Occasionally, the losses may lead to total devastation in the absence of such protection.

Among the hardwoods, poplar species regenerate very well after cutting, mainly through root suckering, and they usually become a hindrance to the reproduction of softwoods. Most other hardwoods encounter practically the same difficulties as the softwoods in reproducing themselves after cutting.

MAJOR REMEDIAL TREATMENTS

Ideally, a regeneration plan is formulated well in advance of timber harvesting. The first prerequisite is that the plan must be based on a thorough evaluation of the forest ecosystem under consideration, with particular attention given to its productive capacity (wood volume per unit area, or tree height/age relationships), its soil (type and depth of organic overburden, texture, structure, petrography and depth of mineral materials, position of water table, and long-term moisture regime), its topographic position and microclimate, and its successional tendency in terms of vegetation changes after disturbance. The regeneration plan is then to include specifications pertaining to the type and season of harvest cutting plus the types and sequence of silvicultural treatments needed—all in view of the preselected tree species that best fit the anticipated environmental conditions.

Throughout Canada, clear-cutting is the most common method of harvesting softwood timber, although cutting in a strip-like fashion is slowly gaining popularity under some conditions. In mixed stands, selection cuts are often practiced, but only to the extent that the more valuable individduals are removed while the others are left standing. The use of seed-tree systems is restricted to a few isolated instances.

Good records of treatment costs and results in terms of regeneration are extremely beneficial, because they aid in planning future operations. However, a knowledge of the costs alone verifies the expenditures and nothing else. It may cost, for example, about twice as much to scarify and plant than to scarify and seed (Waldron 1973). Scarification costs alone can be somewhat less than one-third the total cost of scarification plus planting and somewhat more than one-half the total cost of scarification plus seeding (Richardson 1973). Moreover, the cost of burning can be about one-third or less the cost of scarification. In short, none of this shows how much really can be accomplished by manipulating the treatments according to the costs unless one has reliable data on the conditions of the resulting young stands some 10 years or more after the treatments. Unfortunately, very few data of this kind are currently available, and results of much shorter duration will have to be used in selecting treatment combinations.

Mechanical Scarification

In practice, scarification includes all degrees of mineral soil exposure, from very minimal to extreme. It is designated to improve the conditions for either planting or seeding. The exposure may be at random with considerable intermixing of organic materials, in parallel furrows, or in uniformly spaced scalps. Among the equipment currently used are: (1) diverse bulldozer blades, multiple disks, drums, and anchor chains for more or less random scarification; (2) plows, rippers, and disk trenchers for scarification in furrows; and (3) various spot cultivators for scarification in scalps (Cayford et al. 1967; Cayford and Bickerstaff 1968; Hellum 1973; Richardson 1973; Rudolf 1973; Waldron 1973; Norman 1978). The use of anchor chains for simultaneous scarification and slash redistribution on jack pine sites soon after cutting usually results in good regeneration without additional treatments (Ball 1975). The seed in this instance is released from cones in slash by the heat of solar radiation.

Controlled Burning

The use of burning for silvicultural purposes is proving to be of considerable value. A controlled fire usually burns the slash, aerial parts of vegetation, surface moss and litter, and depending on site and weather, varying quantities of the underlying mor or peat. The organic materials remaining after the fire normally include charred stumps and other large pieces of wood, partially burned mor or peat and unburned plant roots in such mor or peat. These conditions are usually adequate for planting softwoods, and if the fire burns deep enough into the mor or peat, they can be favorable also for the reproduction of softwood by seeding. However, complete burning of the forest-floor materials is neither required nor desirable. The best fire-produced seedbeds on moderately dry to moderately moist upland sites are in those situations where exposed mineral soil and thin residual mor alternate, and both have uniform areal distribution. Deeper mors and lowland peats, which normally occur on moist to very moist sites, become favorable seedbeds as soon as the fire burns off the loose, surface moss and litter. Means of selecting the proper conditions for burning the desired amounts of mor or peat are already available (Chrosciewicz 1959, 1967, 1968, 1974, 1976, 1978a, 1978b, 1978c).

Planting

Nearly all regeneration programs involve planting bare-root stock, and the most common practice is to plant by hand using the slit method (Cayford and Bickerstaff 1968). Poor tree survival in some of the older plantations is attributable to excessive plant competition and deficient site preparation. However, survival substantially improves when the planting follows mechanical scarification or plowing. The results are also generally better when the stock is planted early in spring instead of in the fall (Froning 1972). Planting the bare-root stock on controlled-burn sites normally leads to good tree survival and good rates of growth (Chrosciewicz 1978d). The common occurence of "J-roots" (Van Eerden 1978) can be eliminated by proper positioning of the transplants when the slit method is used.

After years of experimentation with various container-grown stock, it appears now that the provision of vertical ribs within both the BC/CFS styroblocks and the Spencer-Lamaire root trainers (Carlson 1979) should solve the problem of major root deformities such as spiralling and kinking (Johnson and Walker 1976; Carlson and Nairn 1977). Both of these containers are used to produce "plugs" that are outplanted in the field without the containers.

Direct Seeding

This operation may involve spot seeding with special cultivators that automatically release a few seeds on each scarified scalp. It may be done as row seeding by using some other devices that space the seeds evenly along the plowed furrows. In addition, standard cyclone seeders may be used in some situations where postscarification broadcast seeding is the objective; this can be carried out by covering the ground on foot, by snowmobile, or by aircraft. Because the amount of seed sown and the season of seeding vary considerably from operation to operation and from species to species, the results are extremely erratic. Understocking seems to be the most frequent problem, although when a seeding operation is successful there may be a problem of overcrowding. Density adjustments, either by filling in the regeneration gaps or by thinning the overcrowding when it occurs, often are required following direct seeding (Hellum 1973; Richardson 1973; Rudolf 1973; Waldron 1973). Spring broadcast seeding on controlled-burn sites usually results in successful regeneration, in terms of both adequate stocking and rapid growth (Chrosciewicz 1970, 1974, 1978d). Indications are that, with improvements in timing and application, direct seeding can become a very useful alternative to planting.

Seed-Tree Systems

Generally, very little work is being done using this method, although controlled burning under seed trees is usually highly successful in terms of forest regeneration (Chrosciewicz 1959, 1976, 1978d). The seed-tree method, however, is applicable primarily to the tree species such as jack pine, lodgepole pine, and to some degree black spruce that develop and store large quantities of seed in tightly closed cones. When fire burns underneath, the heat triggers cone opening and thus aids in seed dispersal. Other species such as white spruce, for example, do not possess this capacity but develop and freely disperse their seed at irregular intervals. This differentiation in both production and storage of seed must be considered when the use of seed-tree systems is contemplated.

FUTURE RESEARCH

In conclusion, this brief overview shows that there is a considerable body of knowledge in the field of forest regeneration, but it has to be better utilized for the site-specific needs that may arise. The time of intensive forest management is not too far away, and we must be prepared through research to take a meaningful part in its implementation.

LITERATURE CITED

Ball, W. J. 1975. An appraisal of natural regeneration on scarified jack pine cutovers, Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-136.

Bowen, M. G. 1978. Canada's forest inventory—1976. Environ. Can., Can. For. Serv., For. Man. Inst. Inf. Rep. FMR-X-116.

Carlson, L. W. 1979. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-214.

Carlson, L. W. and L. D. Nairn. 1977. Root deformities in some container-grown jack pine in southeastern Manitoba. For. Chron. 53:147-149.

Cayford, J. H., and A. Bickerstaff. 1968. Man-made forests in Canada. Can. Dept. Fish. For., For. Br. Publ. No. 1240.

Cayford, J. H., Z. Chrosciewicz, and H. P. Sims. 1967. A review of silvicultural research in jack pine. Can. Dept. For. Rural Develop., For. Br. Publ. No. 1173.

Chrosciewicz, Z. 1959. Controlled burning experiments on jack pine sites. Can. Dept. North. Aff. Natl. Resour., For. Br., For. Res. Div. Tech. Note No. 72.

Chrosciewicz, Z. 1967. Experimental burning for humus disposal on clear-cut jack pine sites in central Ontario. Can. Dept. For. Rural Develop., For. Br. Publ. No. 1181.

Chrosciewicz, Z. 1968. Drought conditions for burning raw humus on clear-cut jack pine sites in central Ontario. For. Chron. 44:30-31.

Chrosciewicz, Z. 1970. Regeneration of jack pine by burning and seeding treatments on clear-cut sites in central Ontario. Can. Dept. Fish. For., Can. For. Serv., Ont. Reg. Inf. Rep. O-X-138.

Chrosciewicz, Z. 1974. Evaluation of fire-produced seedbeds for jack pine regeneration in central Ontario. Can. J. For. Res. 4:455-457.

Chrosciewicz, Z. 1976. Burning for black spruce regeneration on a lowland cutover site in southeastern Manitoba. Can. J. For. Res. 6:179-186.

Chrosciewicz, Z. 1978a. Slash and duff reduction by burning on clear-cut jack pine sites in southeastern Manitoba. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-199.

Chrosciewicz, Z. 1978b. Slash and duff reduction by burning on clear-cut jack pine sites in central Saskatchewan. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-200.

Chrosciewicz, Z. 1978c. Large-scale operational burns for slash disposal and conifer reproduction in central Saskatchewan. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-201.

Chrosciewicz, Z. 1978d. Silvicultural uses of fire in midwestern Canada. Pages 37-46 in Workshop proceedings: Fire ecology in resource management. Environ. Can., Can. For. Serv., North. For Res. Cent. Inf. Rep. NOR-X-210.

Froning, K. 1972. An appraisal of recent plantations in forests of the Prairie Provinces. Can. Dept. Environ., Can. For. Serv., North. For. Res. Cent. Inf. Rep. NOR-X-31.

Hellum, A. K. 1973. Direct seeding in western Canada. Pages 103-111 in Direct seeding symposium. Can. Dept. Environ., Can. For. Serv. Publ. No. 1339.

Johnson, H. J., and N. R. Walker. 1976. Five-year field performance of pine and spruce styroplugs in Alberta. For. Chron. 52:197-198.

Newnham, R. M. 1978. Forest management in Canada (F. L. C. Reed and Associates Ltd.): Summary. Environ. Can., Can. For. Serv., For. Man. Inst. Inf. Rep. FRM-X-104.

Norman, C. M. 1978. Ripper scarification: A silvicultural technique developed in northwestern Alberta. For. Chron. 54:15-19.

Paille, G. 1977. Resolving forest regeneration problems in Canada. Pages 228-242 in Tomorrow's forests. . .today's challenge? Proceedings: National forest regeneration conference. Can. For. Assoc.

Reed, F. L. C. and Associates Ltd. 1978a. Forest management in Canada. Vol. 1. Environ. Can., Can. For. Serv., For. Man. Inst. Inf. Rep. FMR-X-102.

Reed, F. L. C. and Associates Ltd. 1978b. Forest management in Canada. Vol. II. Case studies. Environ. Can., Can. For. Serv., For. Man. Inst. Inf. Rep. FMR-X-103.

Richardson, J. 1973. Direct seeding the spruces. Pages 157-166 in Direct seeding symposium. Can. Dept. Environ., Can. For. Serv. Publ. No. 1339.

Rudolf, J. T. 1973. Direct seeding versus other regeneration techniques: Silvicultural aspects. Pages 29-34 in Direct seeding symposium. Can. Dept. Environ., Can. For. Serv. Publ. No. 1339.

Van Eerden, E. 1978. Roots of planted trees in central British Columbia. Pages 201-208 in Proceedings of the root form of planted trees symposium. B. C. Min. For./Can. For Serv. Joint Rep. No. 8.

Waldron, R. M. 1973. Direct seeding in Canada 1900-1972. Pages 11-27 in Direct seeding symposium. Can. Dept. Environ., Can. For. Serv. Publ. No. 1339.