PRESCRIBED FIRE FOR SITE PREPARATION IN WHITE AND RED PINE

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*Prescribed fire is a promising technique for the preparation of seedbed of the quality needed for the regeneration of white pine (*Pinus strobus *L.) and red pine (*P. resinosa *Ait.). Its twin effects are the removal of duff and the control of competing vegetation. A scheme for pine management based on prescribed fire and partial cutting has been worked out at Petawawa.*

*Le brûlage dirigé constitue une technique prometteuse pour la préparation de lits de germination conformes aux normes de qualité requises pour la régénération du Pin blanc (*Pinus strobus *L.) et du Pin rouge (*P. resinosa *Ait.). Il a pour double effet d'enlever la litière et de contrôler la végétation concurrente. On a mis au point à Petawawa une méthode d'aménagement des pineraies fondée sur le brûlage dirigé et à la coupe partielle.*

INTRODUCTION

It is generally admitted by forest managers that modern logging methods do not favor the subsequent regeneration of white pine (*Pinus strobus* L.) and red pine (*P. resinosa* Ait.). The Ottawa River Valley has received two free crops of pine, the first a gift of nature to the early loggers, and the second an incidental result of early logging methods and the inevitable fire. Achieving a third crop will not be so easy. Apparently the ecologies of white and red pine are not well suited to the conditions resulting from modern logging methods and the exclusion of fire, and special silvicultural treatments become necessary. Any untried technique that is potentially effective and economical deserves an honest, serious appraisal.

Such a prospective technique is prescribed fire. (In this concept we include both site preparation and natural regeneration.)

There is plenty of evidence that white and red pine in the natural state benefit from fire of a certain periodicity and intensity--red pine more so than white pine--and the reason for this lies in the regeneration requirements of these species. The optimum conditions are fairly well known:

1) a seedbed either bared to mineral soil or with its duff cover substantially reduced
2) relative freedom from competition by shrubs and understory trees of undesired species
3) a live overhead seed source
4) considerable opening in the overhead canopy

Site preparation is required to achieve the first two conditions. On an area so prepared, if the last two conditions are met, good regeneration of both pine species will usually result; without such preparation, however, pine regeneration will usually fail.

Research into the use of prescribed fire as a technique for regenerating white and red pine began at the Petawawa Forest Experiment Station in 1959, and has been pursued more or less continuously since then. Two questions were posed at the outset: 1) Can regeneration of these pines be accomplished through the use of fire? 2) Is the process practical? We can now answer both questions with a definite yes. Altogether some 30 areas have been treated with fire, many of them more than once, under various stand conditions and combinations of stand conditions and fire weather. These trials have demonstrated the conditions essential for a safe, effective fire that can lead to adequate white and red pine regeneration. The remainder of this paper deals with some specific aspects of the technique, and includes a proposed method for the use of fire in red and white pine management.

SEEDBED

White pine will germinate and survive on a litter surface over several centimetres of duff, but it prefers mineral soil. Red pine, on the other hand, requires a seedbed bared to mineral soil, or nearly so. The proportion of the duff layer consumed by fire depends mainly on its moisture content. The desired effect is a moderate degree of duff removal, enough to create adequate seedbed for both pines, but not enough to open the way to erosion or to cause unnecessary loss of nitrogen and phosphorus through volatilization. The degree of duff removal varies from place to place, and a patchy effect is quite satisfactory.

BRUSH AND UNDERSTORY COMPETITION

A good seedbed is not enough; on good pine sites especially, the competition from shrub and understory tree species must be sharply reduced to permit the pine seedlings to survive and grow well in the first few years. In this region, the main competing species are hazel (*Corylus cornuta* [L.] Mill.), red maple (*Acer rubrum* Marsh.), and balsam fir (*Abies balsamea* [L.] Mill.). Balsam fir can be eliminated by one fire, but the hardwood competition sprouts or suckers and generally requires two fires for adequate control. The aim is not to eliminate hardwood tree and shrub species completely--that would be ecologically undesirable--but merely to reduce their quantity and vigor temporarily to favor the establishment of a new pine crop.

In our experience, prescribed fire normally kills all brush-sized stems as well as tree stems up to about 10 cm DBH by girdling the cambium. White birch (*Betula papyrifera* Marsh.) of larger size may be killed if its bark burns intensely all the way to the top. Sapling conifers may be killed by cambium girdling, by crown scorch, or by torching out.

FIRE INTENSITY AND OVERSTORY DAMAGE

Natural regeneration implies a live overhead seed source, and the question of damage to the standing trees then arises. Our experience is that the main mortality mechanism in pines is scorching of the crown foliage rather than overheating of the basal cambium. (The term "scorching" as used here means killing by hot convection gases, not actually flaming combustion.) We have found that large pines will stand the loss by scorching of up to half their crowns with less than 10% mortality. The height to which crowns are killed depends directly on fire intensity and flame height. A reasonable fire intensity is about 400-600 kW/m, corresponding to a flame height of up to a metre or so. Occasional surges of higher intensity may damage or even kill a mature pine or group of pines, but these can be salvaged in the partial cut that follows the fire treatment. We have observed little or no fire scarring on crop-sized pines following fire. Generally, if a fire is intense enough to cause fire scarring on mature pines, it will kill the tree by crown scorching first. In brief, a prescribed fire that is carried out properly will result in very little damage in mature pine stands, with no measurable effect on the subsequent growth rate.

EFFECTS OF PRESCRIBED FIRE ON SOIL AND SITE QUALITY

The purpose of prescribed burning in red and white pine is to convert the soil surface temporarily into a medium that favors the establishment and early growth of pine seedlings. The effect of direct

heat on the soil is slight, since only patches of mineral surface are created, and these result from gentle smoldering rather than prolonged intense heat. During burning some heavy mineral nutrients are ashed into a more readily available state; some nitrogen and phosphorus are also volatilized and lost in the smoke. However, according to both the literature and our own data, the nutrient losses are a small part of the total capital, and are in any case soon replenished to the normal equilibrium level by income through rainfall and other sources.

There is also the question of the minor vegetation. We have found that almost all the minor plant species growing in the red and white pine forest have regeneration mechanisms that have apparently evolved in the presence of periodic fire. Thus, within a few years after prescribed burning, essentially the whole species spectrum is present and flourishing. This includes the woody understory species, which are reduced but never eliminated.

Since fire is a treatment to be contemplated only once or twice per rotation, the effects should be viewed in that perspective. There is also the argument that all pine sites have been exposed to fire of varying intensity probably a hundred times or more since the original soil was laid down, and that permanent changes of any sort as a result of further fire are unlikely. In our opinion, the effects of prescribed fire on long-term site quality are transient and insignificant.

FITTING FIRE INTO A MANAGEMENT SYSTEM

Except for white pine on the drier sites, all good stands of red and white pine are of fire origin. Nature, of course, did not worry about the loss of a fair proportion of the mature pines, as long as enough remained alive to provide an adequate overhead seed source. The ecology of the red and white pines thus favors even-aged management, with a pronounced overlap at the end of each rotation to provide seed and a nursing function for the new stand in its first several decades. This suggests some sort of partial cutting system in which fire is used to induce the new crop, the final cut in each rotation taking place some years after regeneration has been initiated. The question is, exactly how should the fire be fitted into the schedule?

In our experience, prescribed fire after a partial cut is very difficult. The intermittent slash results in too much high-intensity fire, and pine mortality may be unacceptably high. A better solution, therefore, is prescribed fire in the untouched stand before the first partial cut.

The best time to burn for effective hardwood kill is after the leaves have flushed, when root reserves are at a minimum. However, when hardwood brush is plentiful, summer flammability is very low, and

the first fire must be in spring before flushing. The second fire can, if desired, be run after the leaves are out for the greatest possible effect.

The two fires should be run in consecutive years for best results. The first cut should then be taken within 5 years or so. The occurrence of a good pine seed year just after the second fire would of course be highly welcome. However, strict attention to seed years would complicate the management scheduling severely; besides, the two pines do not necessarily seed well in the same year. In any event, a well-prepared site is receptive for several years at least.

Obviously, the larger the pines, the easier it will be to burn under them without damage. On average-to-good sites, trees of 80 years or more will sustain little or no damage in a properly conducted prescribed fire. Such trees will also continue to grow well for several decades as a residual stand. Stands as young as 60 years can be burned with great care and moderate damage, but operation at such an age in red and white pine could be justified only as a measure to balance a badly regulated age-class distribution in a larger forest.

Some demonstration stands at Petawawa have been both burned and partially cut. There are examples of satisfactory regeneration from 2 to 17 years of age. However, complete removal of the original stand has not yet been accomplished on any one area.

PRACTICAL APPLICATION

It has been said that prescribed burning is an art as well as a science. This may be true, but it should not be a deterrent to honest trial, since the same could be said of many other silvicultural treatments as well.

The Canadian Fire Danger Rating System provides reasonably good quantitative guides to choice of burning day. The limits in use at Petawawa for burning in red and white pine are:

Fine Fuel Moisture Code (FFMC)	-- 90 - 95
Initial Spread Index (ISI)	-- 8 - 16
Buildup Index (BUI)	-- up to 52
Fire Weather Index (FWI)	-- 12 - 24

The months of May and June are the most suitable from both the fire and silvicultural points of view. In this region most years provide at least 10 good days plus a number of marginal burning chances. Late April and July are also satisfactory for certain situations.

The nature and density of the understory in red and white pine forests vary tremendously with history and site quality. The pre-burning

preparations and firing pattern must of course be based on an appreciation of both the understory and the topography of the block to be treated. Here are a few general points to keep in mind.

1) If the hardwood brush and understory are heavy, the fire must be run before leaves flush in spring.

2) If the understory is pure hardwood, fire behavior is uniform and predictable, and control is relatively easy.

3) Balsam fir understory complicates fire behavior, and is most difficult when present as distinct clumps that tend to crown and damage the pines above.

4) White birch complicates fire control because of its tendency to produce down-wind spot fires.

5) Headfire is preferred because it spreads faster and interior lines can be lit within a block.

5) Backfire is used when dictated by fuel, weather, and topography.

COST OF PRESCRIBED FIRE

The largest area treated in one afternoon at Petawawa was 12 ha. It was what might be called a pilot-scale operation, and was carried out by five experienced men and a tank truck. A couple of hours of preliminary bulldozer work to secure parts of the area not bounded by roads, followed by several man-hours to patrol them, were necessary. The estimated total cost, including man and machine time, was about $450, or $37.05 per ha. Since fire control is essentially a perimeter operation, the economy of working on larger areas is obvious. There is no doubt that, with good planning, the crew in question could have burned an area several times larger with little more effort.

The fire described above was the first of two conducted on an area with a fairly difficult fuel complex. The second fire a year later, in simple litter fuel, cost about half as much.

CONCLUSION

We believe that prescribed fire is a potentially useful tool in the management of white and red pine, whether the objective be timber management, wildlife habitat, or the maintenance of pine in wilderness areas and parks. Of all site preparation techniques leading to natural regeneration, it is surely the one closest to the natural ecological process, and may be the least expensive as well.

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FOREWORD

The White and Red Pine Symposium held at the Petawawa Forest Experiment Station (PFES), Chalk River, Ontario, September 20-22, 1977, was cosponsored by the Ontario Ministry of Natural Resources and the Canadian Forestry Service. Its purpose was to review developments in white and red pine management, to disseminate information to provincial forest managers, and to attempt to stimulate interest in and improve the management of these two species. Over 110 delegates from government forestry services in Canada and the United States, forest industry, universities and colleges, and consulting firms attended the symposium.

The Proceedings consist of 14 papers and a summary. Abstracts in English and French are included with each paper.

For completeness, the essence of questions, answers and related discussion have been included after each paper.

The use of trade names in the papers presented does not constitute endorsement by the participants or by the organization with which they are affiliated.

The first day of the symposium was devoted to a field tour in and adjacent to Algonquin Park to improvement cuts in pine mixedwoods, shelterwood and strip cuts in pure pine and pine mixedwood stands, and weevil control strips in pine. A morning tour on the third day illustrating over 40 years of research on growth, development and management was conducted in the headquarters area of the PFES. The delegates were shown understory control by fire, red pine spacing trials, and regeneration obtained by shelterwood, strip cutting and seed tree methods.

The program committee is indebted to those people who presented papers, chaired and reported on the formal sessions, conducted the field tours and contributed in other ways to the success of this symposium.