Understory prescribed burning in red pine and white pine

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The alarming loss of forested areas containing red pine (*Pinus resinosa* Ait.) and eastern white pine (*Pinus strobus* L.) in eastern Canada is a situation that must be addressed promptly by changing management approaches. Since the ecological role of fire in the regeneration and perpetuation of these pines is well known, it makes sense to use fire to maintain pine ecosystems through forest management that uses an understory prescribed burn program. Fears of fire escape and a poor knowledge of applying fire correctly to these ecosystems are the result of poor training in the use of prescribed fire, which normally concentrates solely on post-harvest slash sites; this has prevented extensive use of understory prescribed burning in the past. However, research in Canada, principally using the Canadian Forest Fire Behavior Prediction (FBP) System coupled with the Canadian Forest Fire Weather Index (FWI) System, allows forest managers to develop burning prescriptions that are safe and economical while meeting objectives for seedbed preparation, natural seeding and control of competing vegetation.

Key words: crown scorching, eastern white pine, fire, natural regeneration, red pine, seedbed preparation, understory prescribed burning, vegetation control.

La perte des superficies forestières contenant du pin rouge (*Pinus resinosa* Ait.) et du pin blanc (*Pinus strobus* L.) dans l'Est du Canada constitue une situation alarmante qui doit être rapidement solutionnée par la modification de l'approche retenue d'aménagement. Depuis que le rôle écologique du feu dans la régénération et la perpétuation de ces pins est mieux connu, il est de bon aloi d'utiliser le feu pour maintenir les écosystèmes composés de pins au moyen d'un aménagement forestier qui contient un programme de brûlage dirigé du sous-étage. La crainte engendrée par la perte de contrôle du feu ainsi qu'une pauvre connaissance de l'utilisation adéquate du feu dans ces écosystèmes sont le résultat d'une formation inadéquate relativement au brûlage dirigé qui est normalement concentré uniquement sur les sites d'accumulation de débris après coupe; cette situation a empêché l'utilisation sur une grande échelle du brûlage dirigé à des fins de destruction du sous-étage dans le passé. Cependant, la recherche au Canada, principalement grâce à l'utilisation du Système canadien de prédiction du comportement des feux de forêt (PCF) en parallèle avec le Système canadien d'indice des possibilités de feux de forêt (IPF), a permis aux gestionnaires forestiers d'élaborer des prescriptions de brûlage qui sont sécuritaires et économique tout en répondant aux objectifs de préparation des lits de germination, d'ensemencement naturel et de contrôle de la végétation concurrente.

Mots clés: brûlage en cime, pin blanc de l'Est, feu, régénération naturelle, pin rouge, préparation du lit de germination, brûlage dirigé du sous-étage, contrôle de végétation

Introduction

The regeneration of red pine (*Pinus resinosa* Ait.) and eastern white pine (*Pinus strobus* L.) in eastern Canada has proven to be very difficult. This difficulty arises because conditions are rarely ideal for survival of the pine seedlings on: (1) post-harvest sites and (2) wilderness areas set aside for the preservation of pine ecosystems (e.g., wilderness parks), which are in many cases "old growth" forests where continued natural succession, in the absence of fire, will eventually eliminate the pine component. Regeneration failure has been evident where clearcutting has been utilized to harvest pine stands with a mixed hardwood component (Wray 1986). The use of a strip shelterwood system to provide a source for natural seeding has also met with limited success (Chapeskie *et al.* 1989). Due to this frustration, some forest managers have stopped harvesting mature pine ecosystem sites because of their past failures to adequately regenerate these sites. Regeneration of the pines appears to be assured only on rocky and sandy sites where competition is slight. Historically, the red pine and white pine forests have depended upon wildfire for their survival (Maissurow 1935; Van

Wagner 1970; Holla and Knowles 1988; Day and Carter 1990a,b). However, Quinby (1991) reported that white pine stands in the Temagami Region of northern Ontario are self-replacing. This is probably due to the open, rocky conditions (with little organic soil) of the sites where vegetative competition is minimal. On rich, deep organic soils, which are more prevalent in many areas of the province, regeneration will not result because of the poor quality of the seedbed and the presence of heavy competition. Wildfires have provided a natural means of removing the top portions of the forest floor to provide excellent seedbeds as well as providing an important role in controlling vegetative competition. Many of the mature pines were able to survive these fires due to fire resistance characteristics such as thick, insulating bark, allowing for a plentiful supply of natural seed. Unfortunately for the maintenance of the pine ecosystems, it was the success of provincial fire-suppression efforts over the past century that eliminated many of the wildfires that had historically maintained these pine ecosystems. The survival of Canada's remaining stands of red pine and white pine may depend upon the reintroduction of fire into these ecosystems by forest managers. The failure to do so may result in the continued loss of many of these magnificent ecosystems as they fail to regenerate adequately and are replaced by different climax species.

Reintroduction of fire into pine ecosystems to improve the seedbed through the use of an understory prescribed burning program has been shown to be viable (Van Wagner 1963; Methven

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Figure 1. View of an understory prescribed burn being conducted in a red pine—white pine ecosystem.

and Murray 1974; Van Wagner and Methven 1978; Olson and Weyrick 1987). Even with this knowledge, there is little or no discussion of the use of prescribed fire as a site preparation technique at meetings on pine management (Stine and Baughman 1992). Possibly the reintroduction of fire has not been considered because there appears to be an unfounded fear that these fires, once ignited, would quickly develop into a crown fire, be impossible to control and would kill all the pine trees on the site. This fear may be increased where personnel have had experience with wildfires in immature pine plantations across the province. Fires in immature pine stands have been documented to be very damaging (Van Wagner 1965, 1968; Stocks 1987), and it has been sometimes solely on this basis of experience that the use of fire in mature red pine and white pine ecosystems has been avoided. In mature pine ecosystems, fire behavior is very much different than that experienced in immature pine plantations under the weather conditions that an understory prescribed burn would be normally ignited (Fig. 1). In fact, at times it can be very hard to get a fire to spread along the ground in a mature pine ecosystem, and because of this, conducting the prescribed burn is much safer than on a post-harvest site. Forest managers must recognize that understory prescribed burning has an important place in pine management.

Other than for research, understory prescribed burning in pine ecosystems has seen limited operational use in Canada. In some cases, understory prescribed burning has been tried, but improper application of the prescribed fire has resulted in limited success. A major reason for this is that almost all training and experience with prescribed burning in Canada has concentrated solely on the typical boreal prescribed burn on a clearcut, post-harvest slash site. For an understory prescribed burn, many of the rules are quite different than for broadcast burning of slash and, in fact, may contradict each other at times. This paper was written to review important considerations for conducting an understory prescribed burn so that managers will understand what the technique can accomplish and how to improve its success by avoiding common mistakes.

Objectives for an Understory Prescribed Burn

The primary objectives for conducting an understory prescribed burn are:

1. To produce a good seedbed by removing much of the L and F layers of the forest floor (duff).

2. To control undesired vegetative competition from various shrubs, conifer, and hardwood species.

The main emphasis in seedbed preparation is not to have total exposure of the mineral soil, but rather to remove the L and F layers of the forest floor. During prolonged drought conditions, severe moisture stress of seedlings can occur when root growth is allowed to develop only in these layers since these layers dry out quickly. Retention of the H layer provides a rich nutrient base for seedling development, especially on poorer sandy sites. Methven (1973) felt that retention of the F layer was also important for nutrient cycling. To take advantage of seed production, the final understory prescribed burn must be conducted in the spring of a good seed year.

Balsam fir (*Abies balsamea* [L.] Mill.), which is often a major competitor for pine seedlings in the understory, can be quickly killed by a single fire which girdles the thin-barked stem (Methven and Murray 1974). On the other hand, hardwood species such as beaked hazel (*Corylus cornuta* Marsh.) often require a second burn to control the species successfully (Van Wagner and Methven 1978). The first burn kills only the aboveground portion of the hazel, and stimulates suckering fed by root reserves, but a second burn can eliminate much of the hazel because of depletion of root reserves after the first burn. Van Wagner and Methven (1978) stressed that the aim of burning is not to eliminate the competition entirely but to temporarily reduce its quantity and vigor until the new pine crop is well established. Understory prescribed burning was shown to be a good method of controlling the red pine cone beetle (*Conophthorus resinosae* Hopk.) and the white pine cone beetle (*C. coniperda* [Schw.]) in pine seed orchards (Miller 1978; Wade *et al.* 1989). Since red pine is more shade-intolerant than white pine, a third objective of burning for maintenance of red pine in natural areas is for the removal of portions of the overstory to allow light to penetrate to the forest floor and encourage growth of any new seedlings. Olson and Weyrick (1987) described trials that used prescribed fire to thin dense stands of white pine saplings (15 to 25 years old, with diameters of 5.0 to 7.5 cm), using the fire to girdle the stems.

Silvicultural Characteristics of Red Pine and White Pine

Red pine and white pine have almost identical ranges in Canada extending from Newfoundland westward to include some parts of Manitoba (Hosie 1969). The silvicultural characteristics of both species that enable them to withstand the heat of an understory prescribed burn are: (1) the height of the individual mature trees and (2) bark thickness. Mature pine trees can reach heights of 30 m, with a diameter of 1 m, although older individuals can grow to a height of 50 m with a diameter of 1.5 m (Hosie 1969). The distance of the live crown of mature trees from the ground and the prescribed fire, which is ground-based, prevents the fire's heat from convecting upwards into the crown and causing foliar damage, which is commonly referred to as crown scorch. Bark thickness close to the ground may range from 2 to 5 cm (Hosie 1969) which provides adequate insulation from any heat damage to the cambial layer from the fire. To meet the conditions of adequate height and thick bark, pine trees should be at least 80 years old (Van Wagner 1993). These species are unlike the thin-barked jack pine (*Pinus banksiana* Lamb.), which is easily killed by most fires.

Since the mature pines remain alive after the understory prescribed burn, there is a natural source of seed from these seed trees that can germinate on the fire-prepared seedbed. Cone development on white pine occurs over 2 years. Pollination occurs around the middle of June and fertilization follows 1 year later in July. The cones reach maturity in September of the second year, reaching their full length of 7.5 to 20 cm (Hosie 1969). With the visible part of cone development spanning two growing seasons, it is possible to predict a potentially good seed crop year well in advance and to schedule the prescribed burn to coincide with the seedfall. White pine has good cone crops every 3 to 5 years (Burns and Honkala 1990).

Red pine's female strobili develop in late spring and pollination occurs soon after. Fertilization takes place in July of the second year, followed by dispersal of seed in the fall which may continue through the winter and into the next summer (Burns and Honkala 1990). Seed production usually begins on trees around 20 to 25 years old and good seed crops occur every 3 to 7 years. Optimum seed-bearing age for both species occurs from 50 to 150 years of age (Lancaster and Leak 1978; Burns and Honkala 1990). Seed yields can be impressive, with up to 865,000 seeds ha^{-1} during a bumper seed year for red pine (Horton and Bedell 1960) and up to 4,500,000 seeds ha^{-1} for white pine (Graber 1970).

White pine is classed as intermediate in shade tolerance. It requires a minimum of 20% of full sunlight to survive during the early seedling years (Wilson and McQuilkin 1963). During the first 5 years after germination, white pine grows so slowly that it may not exceed a height of 0.3 m. After 5 years, it will grow longer leaders. A light level of 55% of full sunlight will provide optimum height growth but not volume growth (Logan 1959). This lower light level can be an advantage in preventing serious attacks by the white pine weevil (*Pissodes strobi* Peck), since the small diameter of the leader prevents the adult weevil from laying eggs (Logan 1959; Sullivan 1961). This illustrates the need for proper harvesting of the stand after burning using a shelterwood system to retain proper light levels until satisfactory regeneration has been established; this will promote height growth while preventing any serious weevil damage. The first cut can occur immediately after burning to avoid damaging any new regeneration. A final cut should not be attempted until the pine leaders are past the height of the active environment for weevil activity, which is approximately 6 m (Sullivan 1961) to 10 m (Rose and Linquist 1973). Under shaded conditions, the micro-environment is also cooler which retards weevil development (Katovich 1992). The ability of white pine to grow under a partial canopy helps to protect the trees from white pine blister rust (*Cronartium ribicola* J.C. Fischer), since little dew forms under the canopy, reducing germination of rust spores (Stearns 1992).

On the other hand, red pine is shade intolerant. This requires that portions of the overstory be removed more quickly for the red pine than for the white pine ecosystem. This can be done by the first cut of a shelterwood harvesting method. In areas where the red pine ecosystem is being managed naturally and harvesting is prohibited, Van Wagner (1970) suggests that the prescribed fire be used to thin the canopy. In this case, the prescription for the understory prescribed burn is developed so as to produce sufficient heat to actually kill some of the pine trees by crown scorch. This indicates that it is difficult to prescribe a burn and manage for both species together.

Behavior of Understory Prescribed Fire

The goal for conducting an understory prescribed burn is to produce a fire that can prepare the seedbed by consuming the L and F layers of the forest floor, kill the aboveground portions of any hardwoods present, yet not be so intense that it will cause crown scorching of the mature pine trees. This preferred type of fire should have a flame length of no more than 1 m (Van Wagner and Methven 1978; Van Wagner 1993) and a frontal fire intensity (the rate of heat energy release per second per metre of fire front) (Merrill and Alexander 1987), of between 400 and 600 kW m^{-1} (Van Wagner and Methven 1978). Olson and Weyrick (1987), however, described the use of a less-intense fire, where a backing fire with flame lengths of 7.5 to 12.5 cm was used to thin white pine saplings.

The equation for frontal fire intensity can be adapted from Byram's (1959) equation:

$$I = Hwrl/60 \quad (1)$$

where I represents frontal fire intensity (kW/m), H represents the heat of combustion and is assumed to be constant at 18,000 kJ kg^{-1} of fuel, w represents fuel consumption (kg m^{-2}) and r represents the rate of spread (m min^{-1}) of the fire.

The most important step in conducting a pine understory prescribed burn is to ensure that the burn's frontal fire intensity is maintained below a critical level that will not cause severe crown scorching of the pine trees. Van Wagner (1973) determined a relationship for the maximum scorch height based on frontal fire intensity and ambient temperature (Fig. 2). Although he used wind speed as another variable in other models, understory prescribed burning excludes this variable because wind speeds inside the stand are generally low. This relationship is an important starting point in the development of prescriptions for the fire as part of the overall prescribed burn planning process.

It is important that the prescribed fire's planner takes the time in the planning stages to estimate the height to the live crown of the dominant pine trees (i.e., the trees to be saved). This value can then be used with Figure 2 to estimate the maximum frontal fire intensity values before any crown scorching will occur. Once the permissible frontal fire intensity is known, the manager can use the Canadian Forest Fire Behavior Prediction (FBP) System (Forestry Canada Fire Danger Group 1992) and the Canadian Forest Fire Weather Index (FWI) System (Canadian Forestry Service 1987; Van Wagner 1987) to identify safe burning conditions. If partial crown scorch does occur, even after proper planning, managers should not be overly alarmed since tree mortality begins only with 46 to 50% crown scorch and reaches 50% only when 81 to 85% crown scorch occurs (Methven 1971). Even if a tree's crown is severely scorched, it has a better chance of surviving if the burn is completed prior to bud flush (Wade *et al.* 1989). For this reason, managers should allow an ample time period to see whether or not any trees that were badly scorched will flush out and survive. The tree may look dead only until the new foliage flushes once again. A tree that is scorched after bud flush has no means to re-foliate since the new foliage will be killed. On burns where the potential for a number of "hot spots" is high due to fuel buildup created by blowdown, then burning should only be conducted prior to bud flush.

The forest floor (duff) should be the main available fuel, since the burn is conducted prior to any harvesting of the site,

Figure 2. The relationship between crown scorch height, using 4 different ambient temperatures, and frontal fire intensity under no-wind conditions (adapted from Van Wagner 1973).

preventing any buildup of woody-slash fuel. Estimates of forest-floor consumption for red pine and white pine (fuel type C-5) were developed by the Forestry Canada Fire Danger Group (1992) in the FBP System using the Buildup Index (BUI) of the FWI System. Consumption of the forest floor is low (0.3 to 0.6 kg m^{-2}) under most burning conditions compared with that on some broadcast burns, where total consumption can exceed 23 kg m^{-2} in tramped dead balsam fir (McRae 1980). This estimate of duff consumption then becomes w in Equation 1 for determining frontal fire intensity, but would remain constant throughout the day of burning.

Controlling frontal fire intensity in order to prevent crown scorch includes not adding any additional fuels. All pre-fire harvesting of the stand should be avoided to prevent any fuel buildup under the pine trees. This contradicts normal boreal forest management practice, in which all harvesting occurs prior to any site preparation being conducted for regeneration purposes. When this rule is ignored, the result is that considerable damage may occur to the pine trees, resulting in poor survival. This concern can be demonstrated by using Equation 1 to calculate frontal fire intensity for a normal fuel consumption of 0.5 kg m^{-2} and a rate of spread of 2 m min^{-1} , then an intensity of 300 kW m^{-1} is found. This would give a crown scorch height of 5.7 m with a 25°C ambient temperature (from Fig. 2). If, however, the same site was harvested before the fire and this left as little as 1.0 kg m^{-2} of available slash fuel in addition to the available forest fuel of 0.5 kg m^{-2} , then the frontal fire intensity increases to 900 kW m^{-1} . The addition of only this small amount of additional fuel substantially increases the crown scorch height to 11.9 m .

Harvesting often produces wounds on the residual pine trees, from which highly flammable resin oozes. Any fire that reaches this material will quickly ignite the resin and cause extensive damage to the tree as the fire follows the resin streaks. Though the logging and fire-damage wounds will not kill the pine trees which are quite remarkable and can survive with only a small segment of live cambium layer attached, the wounds can initiate stem rot, especially in white pine.

If harvesting of any type has occurred inadvertently, the understory prescribed burn may have to be postponed, especially when the FWI's Fine Fuel Moisture Code (FFMC) is in the range of 90 to 95, as suggested by Van Wagner and Methven (1978). Values this high indicate very dry surface conditions allowing the fire to spread very fast. Burning should not be considered (Fig. 3) until the harvesting residue has broken down to the point at which foliage and slash pieces less than 1 cm have broken off and have been incorporated back into the forest floor. If burning of these sites proceeds, careful planning is required to avoid crown scorch. To reduce frontal fire intensities, the FFMC may have to be lower than what may normally be used for an understory prescribed burn and a backing fire may be required to reduce rates of spreads. The FFMC should not be >90 in these cases, but even at these lower values, difficulties will persist in preventing some crown scorching. Because of this, no burning of harvested sites should take place after bud flush. Sites that fall into this category are generally those that have been previously harvested using a shelterwood system, where many of the pine trees have been retained on the site but regeneration has failed due to poor seedbed preparation and severe competition on the site and fire is prescribed to remedy the situation. This is not the preferred method of using understory prescribed burning, but if carefully planned, it can be utilized even where the proper sequence of silvicultural events has not been carried out.

Sometimes increases in fuel loads arise naturally from blowdown as a result of windthrow of unstable trees. Because this usually involves only a small portion of the burn area, it is not worthwhile to postpone the burn only for this reason. Options in conducting the burn in these cases, because the downed woody fuel occurs only in small pockets, may be: (1) to do nothing, especially if the fuel is not under any dominant pine trees, (2) to physically remove the fuel from the site, or to cut and scatter the fuel over a wider area, or (3) to pile the fine material and burn it in the autumn before the understory burn when conditions will be such that only a low-intensity fire will develop.

Figure 3. View of a prescribed burn in which high slash fuel loads as a result of harvesting will result in high frontal fire intensities (note flame lengths), which will cause severe crown scorching of the residual white pine seed trees.

Fire managers must carefully consider their ignition strategy and the effect it will have on the rate of spread (r in Equation 1). Estimates of rates of spread may be obtained from the FBP System (Forestry Canada Fire Danger Group 1992) for the red pine and white pine fuel type (C-5), which uses the Initial Spread Index (ISI) of the FWI System to make this prediction. Rates of spread are much slower, ranging from 0.1 to 4.0 m min⁻¹, than those on prescribed burns conducted on post-harvest slash areas. Topography is an important consideration when considering ignition, since slopes can drastically accelerate rates of headfire spread up the slope (Van Wagner 1977). A slope of only 50% has a spread factor of 4.7, which means that a headfire will spread 4.7 times faster going up the slope than on level ground. Because of this, most slopes should be burned with a backing fire to control the rate of spread, and hence the frontal fire intensity, to prevent crown scorching. Slope factors (SF) can be easily obtained from the FBP System.

Grid-type ignition, where a number of individual fires are ignited throughout an area and which commonly occurs with all aerial ignition methods, should be avoided at high FFMC values (90 and above). The reason for this is that intense flareups, associated with junction-zone effects, must be avoided. Junction zones are areas of the fire in which acceleration

of the fireline increases due to the convection action created by previously ignited areas of the burn or when two fires merge. This is easily illustrated by bringing two lighted matches together and observing the response in flame length. Because of lower rates of spread at an FFMC of 89 and below, junction-zone effects will be not as dramatic and increases in frontal fire intensities will be tolerable as long as fuel loads are relatively low. Prescribed burns when the FFMC is 89 or less should be conducted before the leaves of understory species emerge.

Ignition at an FFMC of 90 and above should proceed only with hand ignition, with a solid fireline strip being ignited, which will keep ignition costs low compared to aerial ignition. Initial ignition may be a backing fire lighted beside a wet or foam line when a road can not be utilized as a boundary. If a control line is deemed necessary, it may be constructed using a shovel and need not be more than 0.5 m wide to be effective. Because of the low-intensity fires used, there is no need to use a bulldozer to construct a wide control line, which is both costly and unsightly. Once the initial backfire has burned out a sufficient area from the control line, a number of strip headfires may be ignited with the number depending upon the burn's size. Planning for these firelines must consider reducing their number to reduce junction-zone effects as the headfire of one strip meets up with the backfire of an earlier-lit fireline. At the same time, sufficient firelines must be lit to ensure that the entire area will be burned in one burning period, generally an afternoon. Distances between firelines will depend on the expected rate of spread, as determined by the FBP System. Where practical, the goal is to have the fires join up late in the day, when fire danger is less because of increasing nightly humidity, thereby further reducing junction-zone effects.

Time of Burning

Understory prescribed burns, especially on sites being burned for the first time, are generally scheduled for the spring. The reason for this is the difficulty in getting fire to spread in the understory once the understory leaves have emerged, which increases the moisture level of the microclimate at ground level. Sites with a heavy hardwood understory of maple (*Acer* spp.) and hazel will experience this change sometime during the late part of May or early June, depending on latitude. Shrub-poor, parklike sites will not experience this change and the burning season can be extended into the summer period. Litter fall is heavy enough that sites can be reburned the year after the initial burn for hardwood control. A second burn can be ignited later into the summer months due to reductions of the aerial portions of understory species after the first burn. This indicates sites with heavy maple/hazel understoreys should be prioritized so that they are conducted at the beginning of the year, with reburns and shrub-poor, pine-dominant sites being conducted later in the year.

Forest ecosystem classification (FEC) systems, such as the FEC for northwestern Ontario (Sims *et al.* 1989), provide a quick means of identifying this timing. Red pine and white pine sites (Vegetation Types V27 and V26, respectively) will possibly have a longer burning season than red pine and white pine mixed-woods (Vegetation Types V13 and V12, respectively). Sims *et al.* (1990) confirm this for the red pine-conifer stands (V27) by stating that this type typically exhibits a sparse understory.

Needle litter is the most flammable part of the forest floor, followed by leaf litter and feathermoss. Higher FFMC values

are required for the leaf litter to burn as a result of compaction of the leaves, which prevents them from drying as quickly as other duff fuels. Total moss cover in Northwestern Ontario, such as broom mosses (*Dicranum polysetum* Sw.) and feathermoss (*Pleurozium schreberi* [Brid.] Mitt.), averages 14% in mixedwood red pine stands (V13), 37% in red pine-conifer stands (V27) and only 12% in white pine-conifer stands (V26) (Sims *et al.* 1990). Moss cover is insignificant in the herb- and shrub-rich understory of white pine mixedwood stands (V12). This moss since it is alive requires the higher FFMC values to burn well. Problems with fire spread, as a result of emerging understory leaves which increases the moisture levels, are delayed later on feathermoss sites than on leaf-litter sites. Olson and Weyrick (1987) found in their thinning trials that a backing prescribed fire burning in pine needles, with flame lengths of 7.5 to 12.5 cm, would kill most of the stems with a base diameter of < 2.5 cm and kill some of the 5.0–7.5 cm diameter class. However, when the fuel was made up of leaf litter, they found that the fire killed most of the stems < 7.5 cm in base diameter.

Planning Considerations

Proper management of the pine ecosystem is a long-term planning process, perhaps more so than with any other forest ecosystem in eastern Canada. The use of understory prescribed burning re-emphasizes this need for a long-term commitment. This contrasts with most other silvicultural systems in eastern Canada that are presently being employed, for which serious considerations of site preparation are often not considered until after the harvest. When harvesting will take place in pine ecosystems, enough lead time to burn the site properly and to ensure proper regeneration is required. In some cases, a site may require two or three burns prior to a harvest, depending on seedbed quality, sprouting of hardwood competition and the occurrence of good seed years. Planning may need to be started as much as 10 years before any harvesting activities. This may seem excessive in terms of our present management approach; however, if the pine ecosystems are indeed valuable and there is a desire to retain this natural heritage, then there should be no deadlines as to when the harvest should take place. Rather, the emphasis should be placed on proper pine regeneration to ensure that the site does not undergo succession to other tree species. This may disrupt the supply of logs to the mills until a proper cycling of pine sites in a region is developed. The present management attitude of cutting and then worrying about regeneration cannot be tolerated if we wish to stem the continued loss of our pine ecosystems that is being experienced. Even with adequate regeneration after a successful understory prescribed burning program, proper shelterwood harvesting techniques must be employed to ensure continued survival of the young pines and to prevent problems such as white pine weevil damage.

Unlike prescribed burning on a clearcut with heavy loads of slash, which is often a one-time event regardless of its success, the understory prescribed burn can be conducted several times on a site to get the desired effect. A site may be burned again if a proper seedbed was not produced (i.e., not all of the L-layer was consumed), if severe hardwood resprouting occurs, or if a good seed year fails to occur within 2 to 3 years after burning. The decision to reburn must be assessed for the latter two reasons, not immediately after the last burn, but later by regular visits to the site to assess conditions.

Conclusion

A method for managing red pine and white pine ecosystems, understory prescribed burning, has been described. The technique has not been well utilized in the past because of the lack of information on successful completion of a burn. The real challenge now is for managers to implement understory prescribed burning in their operational programs so that areas of our dwindling pine ecosystems will be maintained and possibly increased for future generations of Canadians. Implementation of an understory prescribed burning program would fit nicely into recommendations given by groups such as the Old Growth Policy Advisory Committee (1993) in Ontario, to "use silvicultural techniques that promote the regeneration of red and white pine, preferably by natural means."

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