Regeneration Silviculture of Aspen¹

by

René Doucet²

Abstract

Factors affecting the regeneration of aspen are reviewed. In many cases, complete clearcutting will ensure prompt restocking at a satisfactory level without the need for further treatment. However aspen has traditionally been underutilized, and this led to the development of decadent stands. Special treatments may be needed to regenerate them. Moreover, aspen has such a large range that regional adaptations may be necessary for consistent success. Clonal differences have been used to a small extent to improve natural stands through silvicultural manipulations, but the potential of such techniques is low, as opposed to the use of genetic variations to develop more productive hybrids.

Résumé

L'auteur passe en revue les différents facteurs qui affectent la régénération du tremble. Habituellement, la coupe totale suffit à assurer, par drageonnement, la régénération complète des trembles. Toutefois, on trouve beaucoup de peuplements décadents, par suite de la sous-utilisation chronique de la ressource dans le passé. Ces peuplements peuvent poser des problèmes particuliers. De plus, le tremble occupe une aire géographique si vaste, que des différences régionales peuvent demander des adaptations. On a parfois tenté, par des manipulations sylvicoles, d'utiliser les différences clonales pour améliorer les peuplements naturels, mais cette technique ne semble pas avoir beaucoup d'avenir, contrairement à l'utilisation des variations génétiques pour la production d'hybrides plus productifs.

Introduction

Aspen is widely distributed across Canada. Traditionally, it has been much underutilized throughout its range. But dramatic increases in use have occurred recently (Morley 1986; Rinfret 1987; Smith 1987). And with the mills already under construction or planned for the near future, this increase will continue to the point where local shortages may well develop, or have even already occurred.

These developments have led to a renewed interest in aspen silviculture. The purpose of this paper is to review the state of the art in regenerating aspen. Regeneration by seed and vegetative propagation will be discussed, as well as factors affecting them, and the influence of disturbances on reproduction. Early stand development, tree improvement as it relates to regeneration, and control of aspen will also be dealt with. The emphasis will be on information that can readily be used by the forest manager. Although much of what will be said applies to poplars in general, the discussion will centre on trembling aspen (*Populus tremuloides* Michx.).

Regeneration by Seed

Aspen usually begins to produce seeds at about 10 to 15 years of age. Good seed years occur every two to five years, and seeds can be transported over long distances (Maini 1968, Brinkman and Roe 1975). In spite of this, the establishment of seedlings is rare and restricted to moist freshly exposed mineral soil. This is because seeds are shortlived under natural conditions (Maini 1968); they require constant moisture (Fechner *et al.* 1981); and temperatures of 30°C or higher are detrimental to survival and growth (McDonough 1979). These exacting requirements explain why stands of seed origin are rare. However, the few seedlings that do become established may in time, through suckering, form the nucleus for a future aspen stand.

Vegetative Reproduction

Aspen reproduces readily by suckering. Schier (1976) has reviewed the factors controlling the vegetative regeneration of aspen. The triggering mechanism is the suppression of apical dominance. This interferes with the flow of auxins that inhibit the production of suckers, while allowing growth promoting substances to accumulate in the roots. Sucker production is also favored by high soil temperature. Other important factors are light and soil moisture. The effect of light is not so much on sucker production as on growth. As for moisture either a lack or an excess of it is detrimental.

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²Direction de la recherche et du développement, Ministère de l'Énergie et des Ressources, 2700 rue Einstein, Sainte-Foy, Québec G1P 3W8

Table 1. Regeneration after partial and clear cut in an aspen stand

Type of cut	Age of cut*	Aspen regeneration		Percent of quadrats with heavy competition
		Stocking (%)	Height (cm)	
Total	2½	98	187	2
Partial and Total	P = 8½ T = 5½	94	354	34
Partial	8½	85	523	50

*Measurements were taken in early July, when about half of the height growth was completed.

Finally, the density of regeneration is related to the level of carbohydrate reserves in the roots. Age of the parent stand may also play a role, though it seems to have little practical significance when stands are clearcut (Brinkman and Roe 1975).

Methods for Ensuring Successful Rregeneration

One of the most appropriate means of suppressing apical dominance and of promoting suckering is by a true clearcutting. This often results in a sucker stand in excess of 50 000 or even 100 000 stems/ha (Doucet 1979, Crouch 1983, Bella 1986). On the other hand, partial cutting may seriously inhibit suckering: fewer suckers are produced because apical dominance is retained in the stems that are left standing, and these may, through shading, affect survival and growth of the highly intolerant aspen. Although adequate regeneration has sometimes been obtained with a residual basal area as high as 14 m²/ha (Hittenrauch 1976, Walters *et al.* 1982), a basal area of no more than 4 m²/ha is often enough to eliminate many suckers and adversely affect the growth of those that survive (Jones 1976, Perala 1977).

In 1988 I inventoried a large aspen stand growing on a rich moist loam, that had been cut in three stages. In the first one, which affected about half of the area in the summer of 1979, trees larger than 20 cm dbh were taken for veneer, leaving a residual stand of 632 stems/ha (59% aspen), 14.6 m²/ha of basal area (75% aspen) and 88 m³/ha of merchantable volume (85% aspen). Three years later, about half of the portion that had been partially cut was clearcut. Finally a one-step clearcut occurred on a previously untouched portion in the summer of 1985. The most striking difference (Table 1) was in the degree of competition, caused mainly by alder and beaked hazel, which increased from the clearcut to the partial cut. Height of aspen in the one-step clearcut compared with that given in the literature. In the stand that had been cut in two stages, height was clearly inferior, probably because of logging damages in the second cut. Finally the regeneration on the partial cut began to show signs of decline. About 15% of the quadrats no longer had any aspen regeneration and height growth of that present was affected owing to competition from brush and the overstory. Visual inspection showed that aspen stocking would continue to decrease, leaving a stand of irregular density.

Suppression of apical dominance by girdling is not appropriate for sucker production: fewer suckers are produced and their mortality is high. This has been attributed mainly to rapid decay of the root system of girdled trees, coupled with the shading they cast (Schier and Smith 1979).

True clearcutting, as well as brush removal and soil disturbance, also favor higher soil temperatures, thus again

promoting suckering. In a study of aspen regeneration in Saskatchewan, the increase in sucker density after summer cutting was attributed to increased soil temperature brought about by logging disturbance (Bella 1986). This is contrary to other findings where density was greater after winter logging, because carbohydrate reserves in the roots are larger at that time (Brinkman and Roe 1975, Schier 1981). Regional differences may affect the importance of the respective factors. In the southern part of its range, soil temperature is probably not critical to aspen reproduction, while the reverse may be true in the north (Schier 1976). However, even though vegetative reproduction of some hybrid poplar clones has been seriously affected by logging season (Strong and Zavitkovski 1983), this does not seem to be a critical factor with aspen: sucker density is usually adequate no matter when logging is done (Brinkman and Roe 1975, Bella 1986).

Slash will also affect suckering, through its effect on soil temperature. Moreover, it may physically hinder sucker growth. Again, the problem is not too serious, since even a relatively large amount of slash will not normally prevent adequate aspen regeneration (Bella 1986, Jones 1987).

To increase the light intensity reaching the soil, cutting must be as complete as possible and brush must be controlled. These requirements are the same as those previously mentioned.

Rotation length is another factor that can affect sucker production. This is not critical with traditional rotations, but it may become so when biomass production is contemplated. Biomass production can be impressive in young stands (Ruark and Bockheim 1988), but very short rotations have been shown to reduce yields drastically in each successive harvest, due at least in part to a higher incidence of root rot (Stanosz and Patton 1987). To prevent this, rotations of at least 10 to 15 years have been recommended (Perala 1979, Stiel and Berry 1986).

Early Stand Development

The large number of suckers that usually arise after clearcutting is not a problem for stand development. Aspen is very intolerant of shade and stems that fall behind in height growth are rapidly eliminated. Reduction in density is especially rapid in the first five years after establishment (Table 2); during this period, differences in stem number between stands become less and less as time passes. However, densities of over 10 000 stems/ha at 10 to 15 years of age are not uncommon.

Height growth of dominant stems is also very rapid in young stands. Dominant height on average sites is from 1 to 2 m at age 2, and from 3 to 5 m at age 5 (Alban 1985, Bella

Table 2. Change in stand density (N stems/ha x 1000) with age

Stands age (years since cutting)				References
1	4-5	8-10	12-16	
—	16	10	0	Alban, 1985
50-150	30-35	—	12-15	Bella, 1986
35-150 ^a (90-250) ^b	5-15 ^a (20-30) ^b	4-9 ^a (20-30) ^b	—	Doucet and Boivin, 1985
14-51	—	4-9	—	Perala, 1983
129	13	—	14	Schier and Smith, 1979
46-90	17 ^c	8 ^c	5 ^c	Stiell and Berry, 1986

a) aspen only

b) All species

c) estimated from percent survival, 20-year rotation

1986, Morley 1986). Good stands may attain a height of 9 m at age 8 (Perala 1983), while even on poor sites height can be 5.5 m at age 6 (Doucet 1977). At about 15 years of age, heights of 7 to 9 m are easily attained (Doucet and Veilleux 1982; Bella 1986).

Young aspen is prone to attack by several diseases and insects (Gross and Basham 1981; Gross and Syme 1982). The high incidence of injury is considered normal and should not affect yield at a later age (Perala 1984). If a dense sucker stand is obtained, hypoxylon canker, for example, will act primarily as a thinning agent (Ohmann *et al.*, 1978). Stands originating after clearcutting do not seem to suffer more than the parent stands originating after fire (Kemperman *et al.* 1976). The problem may, however, be more serious when regenerating stands are poorly stocked to begin with. It is claimed that a stand must contain at least 10 000 stems/ha at 2 years (Perala 1977) or 6 000 stems/ha at 3 years (Steneker 1976) to be considered as adequately stocked.

Regeneration of Deteriorating or Understocked Stands

Because of past under-utilization, large areas of aspen are overmature (Morley 1986, Jones 1987). Other stands, while not being decadent, may be poorly stocked. Care will thus be needed to secure high stocking level when regenerating them. This can usually be accomplished by felling (Jones 1987) or shearing (Perala 1983). Only about 125 well distributed trees, or 5 m²/ha of basal area are needed in the parent stand to produce a fully stocked stand (Perala 1977, Doucet 1979). When problems do persist, unstocked portions can often be attributed to an absence of aspen in the parent stands (Doucet 1982).

When brush is abundant summer harvesting with full tree skidding will help control it and stimulate aspen suckering (Perala 1977, Morley 1986). However, only the amount of disturbance necessary to control brush should be used, since too much heavy traffic may damage shallow roots and thus decrease suckering (Jones 1976). Herbicides such as 2,4-D can also be used. Aerial portions will be killed, but new suckers will arise from the roots (Perala 1971, Doucet 1986). When treatment is delayed for a few years, diameter and height growth will be temporarily reduced, but no permanent damage will likely result (Basham 1982a). Scarification has also been shown to increase suckering (Weingartner 1980), but height and diameter growth, and stem quality will be adversely affected (Basham 1982b), so that it is not recommended. Finally, a moderate fire will stimulate suckering (Rouse 1986, Brown and

De Byle 1987); a high fire intensity, while not preventing suckering, may reduce sucker density (Brown and De Byle 1987) and height growth (Perala 1977). It must be emphasized that prescribed burning is difficult to conduct in aspen or mixedwood stands or slash (McRae 1985).

Stand Conversion to Other Species

In some cases, the manager will want to convert aspen to another crop. Poor, dry aspen sites may be better suited for other species, since aspen production on these sites is low and the stands may be prone to early deterioration (Schield and Bockheim 1981). Mortality may also be high on moist sites or on those exposed to snow damage (Crouch 1986).

Even on good sites, management objectives may call for stand conversion. This will not be easy, however, because of the prolific regeneration and fast growth of aspen after cutting, scarification, or spraying. In mixed stands, the aspen portion may be harvested a few years before the rest of the stand. Suckering will result but survival and height growth will be affected by the residual stand (Jones 1976, Schier and Smith 1979). Very small clearcuts are also detrimental to aspen regeneration (Ohmann *et al.*, 1976); aspen will not be completely eliminated, but its abundance will be reduced. Girdling can also be helpful, since high mortality will result from rapid decay of the root system and shading provided by the standing trees (Schier and Smith 1979). The use of glyphosate shortly after cutting has also been shown to control aspen regeneration for some time (Perala 1985). In most cases, stand conversion should not mean the complete elimination of aspen, but enough control to permit other species to become dominant.

Tree Improvement

Recent studies (Cheliak and Dancik 1982; Hyun *et al.*, 1987) have shown that large genetic variations exist in aspen populations. This is not surprising since clonal differences have been shown to exist in suckering ability (Garrett and Zakner 1964, Schier 1976), tree longevity (Schield and Bockheim 1981), productivity (Lehn and Higginbotham 1982) and disease resistance (Hiratsuka and Loman 1984). This diversity has been used in developing hybrids, though to a small extent compared with other poplar species, because of the poor rooting ability of aspen cuttings (Anderson 1980), and because range-wide studies of variability do not exist (Zsuffa, 1981).

It has also been suggested that clonal diversity could be used to favor the expansion of desirable clones, through silvicultural manipulation. However, recent studies have shown that very few clones can be classed as superior when both growth rate and decay incidence are considered (Basham, 1987), so that only small gains can be made in this manner (Weingartner and Basham, 1985). Moreover, the potential for enlarging aspen clones through silvicultural manipulations is modest (Perala, 1981).

Conclusion

Aspen regeneration is usually accomplished by true clearcutting; this will ensure the immediate establishment of a dense sucker stand that will not be subject to stagnation. Although density of regeneration may be affected by several factors, such as clonal variability and cutting season, these will not normally have any major effect on future yield, since differences in stand density will rapidly be reduced by the death of surplus stems. Because of low utilization, decadent stands form much of the aspen resource. Regeneration of these stands

may require special treatments, but again these can be applied relatively easily. Poor aspen sites should often be converted to other species, but conversion of good sites will require considerable effort.

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