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RENEWING DECADENT ASPEN STANDS

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ABSTRACT

Aspen (*Populus tremuloides* Michx.) with life left in the crown can usually be regenerated by root sprouts following clear-cutting, bulldozing, shearing, burning, or aerially applied phenoxy herbicide. About 4-5 m^2 basal area per hectare of well-distributed aspen are needed to provide sufficient roots to regenerate full stocking. Some stands regenerate sporadically without disturbance to form multi-storied, uneven-aged stands. Regeneration from seed is possible if mineral soil is exposed by scarification or fire, but it is less reliable than suckering.

INTRODUCTION

As aspen fulfils its expectation as useful raw material and we begin to manage the aspen forest, we notice that we are late in entering some stands. They may be largely intact but so riddled with decay to be unusable, or they may already be broken up into remnants. They likely are economically inoperable and can be renewed only at cost, sometimes with great difficulty or not at all, and with no immediate return. These stands are the focus of this paper, although whatever is said applies as well to stands that owe their decadence to high grading (e.g., Navratil et al. 1990). Prudent silvicultural practices usually prevent regeneration problems in stands that are normally economically operable.

The timing of decadence depends on inherent aspen stability and longevity and the speed of the break-up process. Stand renewal depends on the biological opportunities for regeneration, their limits, and our resolve to intervene with appropriately sound actions.

STABILITY AND LONGEVITY

Aspen is a disturbance-dependent early successional species that usually dominates a site only until it is replaced by more stability-dependent, shade-tolerant species. Most aspen stands are even-aged because they reproduced as suckers immediately after a disturbance. Although aspen clones readily expand into grasslands or shrub lands, human intervention or fire is essential to regenerate aspen on most sites where it is seral. If fire occurs about every 50 years and is hot enough to kill most of the stand, aspen will dominate most sites. Without fire, aspen is usually replaced within a single generation (Mueggler 1985).

Not all aspen stands are seral. Well-stocked, mature stands produce hundreds of ephemeral suckers that grow a few centimetres, die from lack of light, and reappear the next year (Baker 1918). As aspen canopies deteriorate, increased light enables some suckers to grow into saplings. In the west, where conifer invasion can sometimes take more than 1000 years, uneven-aged stands commonly develop this way. If they lack invading conifers, the community is stable—a *de facto* climax—and self-perpetuating. Aspen seems to form relatively stable communities at mid elevations and on southerly exposures; at high elevations and on northerly exposures it usually is replaced by conifers (Mueggler 1985). In the east, succession is determined by soil-water regime (Roberts and Richardson 1985).

Aspen longevity depends on cool growing seasons and therefore increases with latitude and

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elevation. Aspen lives longer on calcareous soils (Shields and Bockheim 1981) and good sites (Baker 1925; Zehngraff 1949; Graham et al. 1963; Fralish 1972), although the oldest reported quaking aspen was 226 years old but only 12 m tall (Strain 1964). In the east, stands start to break up after 40-70 years. In the Rockies, stands commonly attain 120 years, and some persist to 200 years or so (Jones and Schier 1985). Commercial rotations range from about 35 years in the southern Lake States to about 120 years in the Rockies (Graham et al. 1963; Shepperd and Engelby 1983).

BREAKUP

Stand breakup begins when growth slows to the point where canopy gaps caused by mortality cannot be refilled. Heightened stresses from increased wind, sunlight, and therefore evapotranspiration, sap the vigor of the survivors. The process accelerates as more trees succumb and more gaps are created. Breakup takes as little as 3 years in the east (Fralish 1972). In the west, some clones deteriorate so fast that sucker production cannot keep pace with overstory mortality (Schier 1975), and the site converts to conifers or, on dry sites, to rangeland. Sometimes pathogens or defoliating insects can cause premature breakup. Chronically infested stands are inherently poor management risks and should be converted to another cover type (Schipper and Anderson 1976).

Breakup is generally, but not always, coincident with the extensive development of decay that weakens the tree and increases wind loss. Decay incidence and volume, the position and shape of rot columns, and the interaction of these with site quality differs among clones (Wall 1971), although genetics may not be as important as the micro-environment (Weingartner and Basham 1985).

REGENERATION POTENTIAL AND LIMITATIONS

Aspen can be regenerated sexually from seed or vegetatively by root suckering. The latter is by far the most practical, although seedling regeneration should not be totally discounted (Gullion 1990; Navratil et al. 1990). The advantage of an existing, well-established root system to produce numerous root suckers is readily apparent. Root suckers do not require stringent microclimatic conditions, and the genetic character of the new stand is known from the parent stand.

Jones and DeByle (1985), Schier et al. (1985a), and Perala (1991) reviewed the suckering process and limitations. In the west, most suckers arise from roots within 6 cm of the surface, and practically all arise from roots within 12 cm. Parent roots of aspen in the Lake States tend to be shallower, most within 3 cm. Severe burns increase the depth of sucker initiation. Most suckers grow from roots smaller than 1 cm in diameter. Few grow from roots greater than 3 cm.

Sucker development is suppressed by "apical dominance" over the roots exerted by auxin transported from the canopy. When aspen are cut, burned, girdled, or defoliated, auxin levels in the roots plummet. New suckers and preformed dormant primordia, buds, and shoots can then grow. Deteriorating clones often fail to regenerate because auxin even from declining crowns can still dominate the shrinking root system.

Cytokinins (synthesized in root meristems) in high ratios to auxins favor shoot initiation; low ratios inhibit it. These ratios increase when an aspen is cut because auxins no longer move into the roots, and cytokinins no longer move out.

Carbohydrate reserves in the parent roots fuel bud initiation and shoot growth until the shoot emerges from the soil surface and can manufacture photosynthate. Inadequate carbohydrate reserves do not significantly limit the number of suckers initiated but do limit those that reach the soil surface, especially from deep roots. Neither distance from the parent tree nor root age regulates suckering.

Low soil temperature limits suckering. High temperatures increase cytokinin production and may degrade auxin, thus stimulating suckering. Suckering is not inhibited by drought until water is no longer available from deep in the soil profile.

Sucker production varies much among clones, probably reflecting root carbohydrate reserves and hormonal growth promoters. Aspen seems genetically most uniform where environments are most severe; the greatest variation in the west is at intermediate elevations.

Aspen does not tolerate shade. Regardless of size, overtopped aspens deteriorate and eventually die. Sucker regeneration after partial cutting is proportional to the degree of overstory removal. Removing sufficient canopy to allow nearly full light is needed to produce a uniform and vigorous sucker stand.

Sucker production increases asymptotically with stocking of the parent stand. Poorly stocked aspen simply lacks the root densities needed for full regeneration. About 4-5 m^2/ha basal area are needed for adequate regeneration (Perala 1983; Doucet 1989).

REGENERATION PRACTICES

Sound, undamaged suckers are needed to provide a stand that is stocked well enough to meet management objectives. Excessive stocking is seldom a problem because aspen stands constantly thin themselves (Walters et al. 1982; Shepperd and Engelby 1983).

Logging may not be an option in decadent stands unless concessions or payments are awarded the operator. Yet logging, especially clear-cutting, stimulates aspen suckering as well as any treatment (reviews by Perala and Russell 1983; Schier et al. 1985b; Davidson et al. 1989; Doucet 1989; Navratil et al. 1990). Partial cutting produces suckers on fewer roots, and they develop into inferior stands in competition with the overstory (Sampson 1919; Schier and Smith 1979). Partial cutting reduces future yield (Walters et al. 1982) and restricts silvicultural options. Once partially cut stands sprout, future entries can only damage the new stand.

Only when aspen is cut in the dormant season or in spring can suckering be substantial during the ensuing growing season (Schier et al. 1985b). Regeneration generally is adequate when aspen is cut in the summer, although it will not be numerous until the next year. The later in the growing season that suckers emerge, the less hardened and frost sensitive they are in the fall. Sometimes peak sucker production lags for several years (Schier et al. 1985b). Meanwhile, an understory can become more competitive before aspen suckers arise. Clear-cut aspen stands occasionally do not regenerate, especially on level, poorly drained sties (Bates et al. 1990).

Trafficking by harvesting machines reduces suckering in skid trials and landings (Schier et al. 1985b) and can inhibit regeneration over the entire cut area on sites with low soil strength or if operations are prolonged over the growing season (Bates et al. 1990). Aspen regeneration also may fail under excessive slash and felled cull material (Schier et al. 1985b) but seldom on pulpwood clear-cuts having good utilization (Zasada 1972; Bella 1986).

Aspen slash usually is not treated. It is a negligible fire hazard that decays rapidly and is quickly hidden by the dense new growth. Scattered slash also provides suckers some protection from browsing (Schier et al. 1985b).

A fire sufficiently hot to kill an aspen stand will stimulate abundant suckering. A weak fire may only blacken the forest floor, whereas a hot fire can consume it entirely. Solar energy will elevate soil temperatures, depending on how much insulating forest floor remains. The cooler the aspen site, the more advantageous fire is to regenerate aspen.

The heat from an extreme fire can kill roots in the surface 2-3 cm of soil (Horton and Hopkins 1965). Suckering depth can be increased to 10 cm by a hot fire compared to 6-7 cm under a moderate burn (Schier and Campbell 1978). Some suckers will arise after any fire, even if the aspen canopy remains intact (Maini and Horton 1966a), although sucker vigor suffers under a live overstory (Barmore 1968). A fire that kills most or all of the overstory seems ideal, but excessively hot fires should be avoided (Perala 1974).

Where fire can be safely used, it is an efficient regeneration tool, not only for suckers but for aspen seedlings that exploit exposed mineral soil. It is easiest to burn mixed stands having coniferous slash. Burning is best when the surface soil is damp to protect shallow aspen roots and to contain the fire. Hardwood slash is difficult to burn (Perala 1974), but once started, fires can be nearly uncontrollable (Alexander 1982). Many aspen stands, especially those with only an herbaceous understory, do not readily carry fire (Brown and Simmerman 1986).

Herbicides that kill aspen crowns without killing the roots can stimulate good sucker regeneration (Brinkman and Roe 1975). Aerial spraying is inexpensive, and compared to burning, it is less sensitive to weather (DeByle 1976). A water emulsion of 2.8 to 3.4 kg (acid equivalent) per hectare of low volatile 2,4-D ester seems to work well (Brinkman and Roe 1975). Other foliar-active herbicides that kill roots, like glyphosate, might control undesirable residuals like balsam poplar (*Populus balsamifera* L.) without harming aspen if applied after summer logging and before aspen suckers emerge.

Girdled aspen produce few suckers (Smith et al. 1972; Schier and Smith 1979) because favorable cytokinin to auxin ratios do not develop, the root system dies back, and the lingering live crowns cast too much shade.

Wounding or cutting of roots stimulates suckering (Barth 1942; Sandberg 1951; Maini and Horton 1966b; Steneker 1974), even if a root is severed at a single point (Farmer 1962; Schier et al. 1985b). Although disking stimulates understocked aspen stands to sucker, the injury to parent roots is excessive. Fewer suckers survive, their growth is slower, and their internal quality suffers from increased strain and decay (Perala 1972, 1977; Brinkman and Roe 1975; Basham 1988).

Shearing aspen off at the stump with a sharp bulldozer blade can regenerate dense new aspen stands. The parent root system is least disturbed in frozen soils (Perala 1983). Suckering can also be stimulated greatly by bulldozing and tipping aspen out of the ground (Schier et al. 1985b).

Sometimes little deliberate action is needed to regenerate aspen. Grazed stands that have begun to sucker may be completely regenerated by excluding livestock for a few years. Excessive pressure by ungulates can deter aspen regeneration, and limited browsing may suppress apical control and allow abnormally dense stocking. Light browsing forces single dominant shoots and has little effect on stem form (Schier et al. 1985b).

Because dormant-season treatments promote the best suckering, they should be used whenever possible in decadent stands. Only when the preferred treatment, e.g., logging, might not control a strong understory or provide sufficient soil warming should a summer treatment be considered. Decadent stands that we want to renew need all the help we can give them.

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