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Aspen regeneration

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Aspen (Populus tremuloides Michx.) typically occurs in clones produced asexually by root suckering. Seedling establishment is rare due to short-lived seed and demanding seedbed requirements. Most suckers arise from preexisting shoot primordia that are initiated in the cork cambium. Cytokinin produced in roots stimulates suckering while auxin translocated from crowns inhibits it (apical dominance). Disturbances that increase the cytokinin:auxin ratio result in sucker production. Clearcutting is the most efficient method of obtaining aspen regeneration because it reduces apical dominance to a minimum and enables shoots of this shade intolerant species to grow in full sunlight.

Aspen regenerates by seed and vegetatively by root suckers (adventitious shoots). If aspen were solely dependent on seed to regenerate itself, it's doubtful that it would be the most widely distributed tree species in North America. Aspen's clonal growth habit enables it to survive in the dryer parts of its range, such as the mountains of Utah and Colorado, where seedling establishment is rare.

Why are seedlings rarely found in this region? It isn't due to the lack of viable seed, as was once thought, because some seed is usually produced each year and germination percentages of fresh seed are high, commonly exceeding 95 percent (Winton and Einspahr 1981). The scarcity of seedlings is due to short-lived seed, insufficient soil moisture at the time of seed dispersal, and demanding seedbed requirements (Maini 1968; McDonough 1979; Winton and Einspahr, in press). Under natural conditions, the tiny, nondormant seed is viable for only 2 to 4 weeks. Seed
dispersal occurs in June or early July when there is little precipitation and seedbeds are dry. High and continuous availability of water is critical for the survival of the small, delicate, succulent seedlings (McDonough 1979). They are very intolerant of moisture stress and high temperatures at the soil surface.

In those parts of aspen's range where summer precipitation is sufficient, as in the Lake States, seedling establishment is common (Andrejack and Barnes 1969). That is the reason the size of the clones in these areas are smaller than they are in the Rockies.

All aspen clones, of course, must have at one time originated from a seedling. In the case of Utah aspen, this perhaps means going back in geologic time to the Pleistocene, when the climate in this region was wetter and more suitable for the establishment of aspen seedlings (Baker 1925; Barnes 1975). Thousands of years of vegetative regeneration (successive generations of shoots arising on a continually expanding root system), in which wildfires played an important role, produced the large clones that exist today. Some of the more successful are over 100 acres in size and contain as many as 50,000 ramets (Kemperman and Barnes 1976). No other plant species exists in which single genotypes dominate such large areas of land.

In addition to producing root suckers, aspen also regenerates vegetatively by stump and root collar sprouts; however, these are not common (Baker 1918; Maini 1968). They occur with the greatest frequency (<20 percent) when sapling size or younger aspen are killed.

Aspen's shallow, widely-spreading root system, consisting of numerous long, cord-like lateral roots, makes it well adapted for sucker regeneration and clonal development. Suckers arise from meristems initiated in the bark near the cork cambium (Brown 1935; Sandberg 1951; Schier 1973a). These primordia may develop into buds and then elongate into shoots. Frequently, however, growth is arrested at the primordial stage. Development may not be continuous because the physiological requirements for the initiation of a sucker is different from that for its growth. Thousands of suppressed shoot primordia in various stages of development occur on roots of most clones. These appear to be

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1At the same time that shoot development is occurring, the vascular strand is extending, by dedifferentiation of bark tissue, to the root cambium. Eventually vascular connections are established between the shoot and the parent root.
the most important source of shoots when a stand is cut or burned. Rejuvenation (reversion of an adult plant to the juvenile phase) occurs during sucker initiation; this has enabled clones to maintain their vitality during many years of vegetative regeneration (Bonga 1980).

Sucker formation in aspen roots is regulated by the action and interaction of hormones. Cytokinins synthesized in roots stimulate the initiation and growth of suckers (Peterson 1975). Suckering, however, is inhibited by auxin translocated to the roots from growing shoots and leaves, a phenomenon called apical dominance (Farmer 1962; Eliasson 1971a, 1971b; Schier 1973b, 1975a, 1981). To maintain auxin at inhibitory levels it must be continuously supplied because it is rapidly metabolized (Eliasson 1971b, 1972). As long as the cytokinin:auxin ratio is low, suckering will be suppressed (Winton 1968; Wolter 1968). Disturbances that damage, cut, or kill stems will reduce the flow of auxin into the roots and result in aspen regeneration.

If a clone is cut or burned in spring or early summer, shoots will arise the same year. If treatments are carried out after aspen becomes dormant in late summer, suckering will be delayed until the following spring (Schier 1978).

Girdling (removal of a strip of bark from around the stem) might be expected to stimulate suckering because flow of auxin to the roots via the phloem is stopped. In reality, girdling results in production of few suckers (Schier 1978; Schier and Smith 1979). In fact, it's the most efficient method for getting rid of aspen that doesn't rely upon herbicides. The reason: in the girdled tree, upward flow of hormones, water, and nutrients continues in the intact xylem, keeping the crown alive. Thus cytokinins do not accumulate in the roots as they would in a cut tree, and a high cytokinin:auxin ratio, which would be conducive to suckering, fails to develop. In addition, the crown causes the roots to deteriorate by draining the root systems of food reserves.

Apical dominance may have a strong control over sucker regeneration; but this control is certainly not absolute. Drastic treatments are not necessary to stimulate suckering as indicated by regeneration that arises regularly in most clones, by persistent aspen invasion of grasslands, and by shoots sprouting up in lawns when aspen is planted in urban environments. This is not surprising considering the distance that auxin, a relatively unstable compound, must be transported from its source in shoots and leaves to the roots (Thimann 1977). During the long journey, there are many chances of auxin being immobilized or destroyed. The rapid breakdown of auxin at high temperatures is probably the reason that suckers arise on roots.
extending into exposed areas adjacent to aspen, although stimulation of cytokinin production by the same high temperatures could also be a factor (Williams 1972).

Suckering may also occur in the spring prior to bud break and translocation of auxin to the roots. Suckers will arise if soil temperatures are high enough. When the trees have flushed out, apical dominance will become reestablished.

Sucker regeneration usually is not limited by carbohydrate reserves in the roots (Schier and Zasada 1973). Repeated destruction of regeneration on cutovers by browsing, burning, or herbicide spraying, however, will exhaust carbohydrate reserves and result in dwindling numbers of suckers (Baker 1918; Sampson 1919).

Of environmental factors affecting suckering, temperature is probably the most important because of its effects on hormone balances and general metabolism (Maini and Horton 1966; Williams 1972; Zasada and Schier 1973). Light is necessary for good shoot growth after the suckers emerge above the soil surface (Farmer 1963). Aspen, a shade intolerant species, grows best in full sunlight. Availability of water doesn't appear to be an important factor limiting aspen regeneration. Water translocated upward through parent roots from deep in the soil profile enables suckers to survive even during the driest parts of the year (Gifford 1966).

Although there are a number of methods of stimulating aspen regeneration, clearcutting is the most efficient. As long as roots are plentiful and well distributed, as they are in most well-stocked stands, cutting done at any time should result in adequate regeneration. Not only does removal of all stems reduce apical dominance to a minimum, but it also enables suckers of this shade-intolerant species to grow in full sunlight.

Obtaining adequate regeneration is often a problem in deteriorating stands where death of overmature stems has reduced stocking (Schier 1975b). Natural regeneration is inhibited because residual trees maintain apical control over a shrinking root system. Generally root density has declined to such an extent that regeneration following cutting or prescribed burning will be sparse and quite patchy. Follow-up treatments, such as cutting or burning at approximately 20-year intervals, should encourage extension and suckering of roots and eventually cause unstocked areas to fill in.

Our options for managing western aspen today are limited. Lack of markets for aspen wood and a constrained budget makes it difficult for us to actively stimulate aspen regeneration.
Something, however, can be done. Natural regeneration does occur and its survival in many areas is affected by management decisions, particularly those involving livestock and wildlife. Grazing, browsing, and trampling by cattle, sheep, and big game animals seriously impede the growth and survival of aspen suckers. Regulating animal populations and controlling their distribution can contribute a great deal to the success of aspen regeneration and the perpetuation of the species in many areas.

LITERATURE CITED


