Manipulations to Regenerate Aspen Ecosystems

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***Abstract**—Vegetative regeneration of aspen can be initiated through manipulations that provide hormonal stimulation, proper growth environment, and sucker protection—the three elements of the aspen regeneration triangle. The correct course of action depends upon a careful evaluation of the size, vigor, age, and successional status of the existing clone. Soils and site productivity, competition from other plants, and the potential impact of browsing animals upon new regeneration should also be considered. Treatments may include doing nothing, commercial harvest, prescribed fire, mechanical root stimulation, removal of competing vegetation, protection of regeneration from herbivory, and in limited circumstances, regenerating aspen from seed.*

Introduction

Aspen (*Populus tremuloides* Michx.) is the most widely distributed tree species in North America (Little 1971) (figure 1). It occurs in a wide variety of ecosystems and climatic regimes and is a crucial component of many landscapes. Aspen is a disturbance-dependent species that adapted well to the frequent fire regimes that existed in western landscapes prior to European settlement. Several silvical and ecologic characteristics of aspen allow it to fit this role well. Aspen is very intolerant of shade, requiring full sunlight to thrive. Because of this, it is very sensitive to competition from shade tolerant species like spruce (*Picea* sp.) and fir (*Abies* sp.). Aspen can grow on a variety of soils (Peterson and Peterson 1996), but it thrives on deep heavy (clay) organic soils that are often Mollisols (U.S. Department of Agriculture 1975). Although aspen does produce abundant crops of viable seed (McDonough 1979), it reproduces primarily by root suckering throughout most of its western range.

Vegetative regeneration of aspen requires a stimulation to initiate the sucker response. This can be any disturbance that interrupts the auxin/cytokynin balance between roots and shoots, and it stimulates root buds to begin growing. The hormonal imbalance can result from a disturbance that kills the parent trees outright, such as a fire, disease, and timber harvest, or one that only temporarily defoliates the parent, such as a late frost or defoliating insects. This process has been referred to as interruption of apical dominance (Schier and others 1985). In either case, the initiation of bud growth must also be accompanied by sufficient sunlight and warmer temperatures at the forest floor to allow the new suckers to thrive (Navratil 1991, Doucet 1989). Full sunlight to the forest floor best meets these requirements. Even so, young aspen suckers are susceptible to competition from other understory plants and herbivory from browsing ungulates, especially when conditions exist where less than optimal numbers of suckers are produced.

The interaction and co-dependency of these features can be summarized into a model similar to the regeneration triangle used for other species (Roe et al.

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Figure 1—Distribution of aspen (*Populus tremuloides* Michx.) redrawn from Little (1971).

1970; Shepperd and Alexander 1983). Successful vegetative regeneration of aspen is dependent upon three key components: hormonal stimulation, growth environment, and protection of the resulting suckers (figure 2). Each of these factors involves one or more of the silvical characteristics of aspen discussed above. Any manipulation of aspen ecosystems has to satisfy all of these requirements to successfully regenerate the species.

Manipulation Techniques

Manipulation techniques that are potentially available to perpetuate aspen forests include:

Doing nothing
Commercial harvest
Prescribed fire
Mechanical root stimulation
Removal of vegetative competition
Protection of regeneration from herbivory
Regenerating from seed

Choosing the appropriate technique for a given aspen stand depends upon its age, vigor, stocking, associated vegetation, accessibility, the abundance of other aspen in the landscape, and the importance ascribed to maintaining aspen at a particular location. None of the above techniques can be used in all situations.

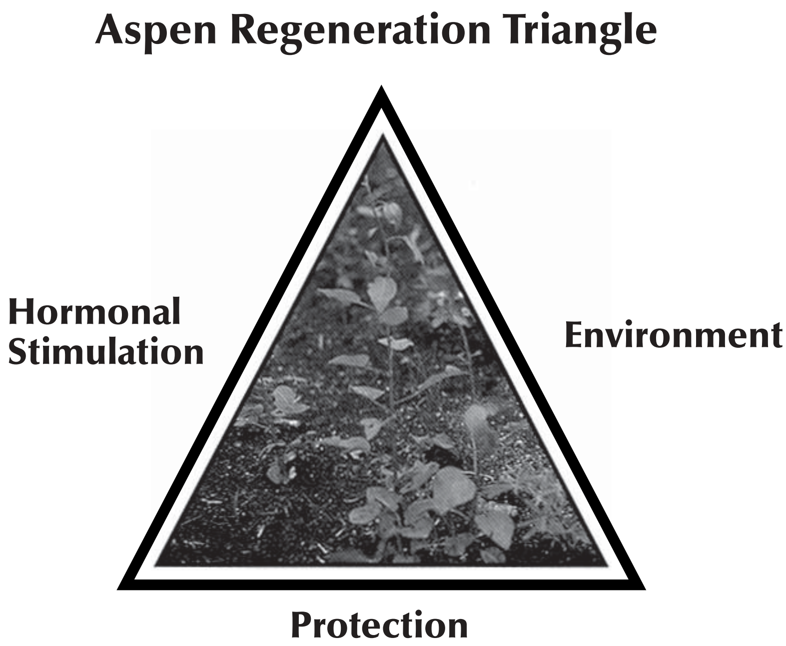

Figure 2—The aspen regeneration triangle illustrates the interdependence of factors that are crucial to aspen regeneration success.

To be successful, a manipulation technique must meet the three requirements of the aspen regeneration triangle, be cost effective, and be technically feasible.

Doing Nothing

Surprisingly, this alternative is often overlooked but appropriate in many situations. Decisions about manipulating individual aspen clones should be based on their health, vigor, and role in the surrounding ecosystem. If a clone is showing little sign of decline, disease, or distress from competition, contains multiple age classes, or is successfully suckering, it is unlikely that any immediate management intervention is necessary to preserve its existence in the landscape. Even clones that are declining may not require active intervention if they are successfully regenerating.

Identifying clones that need to be treated is crucial. Mueggler (1989) presents a general decision model that can be used to prioritize aspen stands for treatment. Aspen stands that are dominated by conifers, or those that are breaking up and not naturally reproducing, are likely to need treatment to rejuvenate the aspen clone. Mueggler further recommends protecting regeneration that is heavily grazed or browsed until it can grow beyond reach of animals.

Although developed for Intermountain aspen stands, these guidelines are generally applicable throughout the West. However, site capability, local conditions, and management objectives will all influence the decision to regenerate aspen. For example, it may be wise to harvest healthy aspen clones to establish new age classes in large single-aged landscapes. Conversely, a declining clone might provide better wildlife habitat than a healthy one in some situations. It is important to remember that what constitutes a desirable condition for aspen in one ecosystem may not be acceptable in another. Each situation needs to be judged in its own context and appropriate action be selected accordingly.

Commercial Harvest

Harvesting aspen for commercial products is a viable means of regenerating aspen forests on operable terrain where an aspen wood market is available and a transportation system exists to remove it. Clearcutting, or (more specifically) clearfell-coppice cutting, is the harvest method of choice in most situations. Removing all aspen at once (including understory stems, if present) best meets all three requirements of the aspen regeneration triangle and will stimulate dense suckering (figure 3). Soil compaction (Shepperd 1993; Alban 1991; Navritil 1991) and nutrient recycling may be problems with some harvesting systems that concentrate tops and limbs at centralized landings.

Partial cutting may be sufficient to stimulate suckering in some clones, but it often does not work well. It is extremely difficult to avoid damage to residual trees while logging a partial cut. Rot and canker disease organisms may be introduced through even the smallest bark wounds and thus, affect the future value of stems that are left. Stems left after a partial cut are also susceptible to breakage, windthrow, and sunscald when exposed to the elements (Jones and Shepperd 1985). Growth of subsequent suckers will be reduced under a partial overstory (Doucet 1989; Perala 1983).

Group selection is an uneven-aged option that may be applicable to managing aspen. The suckering response is usually adequate if group openings are sufficiently large to allow full sunlight to reach the ground throughout most of the area. Harvesting in smaller units partially shades the openings but creates a greater amount of edge between uncut and regenerating aspen than an equivalent area of large harvest units. Smaller openings provide easier access to browsing animals (Timmermann 1991). In one documented case on the Fraser Experimental Forest in central Colorado, cutting small 0.1 ha openings resulted in numerous disease-infected suckers (Jacobi and Shepperd 1991).

Fire

Fire meets all the requirements of the aspen regeneration triangle. It stimulates suckering by killing overstory stems and by killing near-surface root segments and thereby interrupting the flow of auxin to surviving downstream root segments. Fire removes competing understory vegetation and conifer seedlings, and it allows sunlight to reach the forest floor. The vegetation consumed by the fire provides a nutrient pulse for new suckers and the blackened

Figure 3—Aspen successfully regenerated using a commercial clearfell coppice harvest. Uncompahgre Plateau, Colorado.

surface warms soil in the root zone, further stimulating sucker growth (Hungerford 1988). Dense suckering over large burned areas can act as a deterrent to browsing animals (see protection discussion below).

Using fire as a primary regeneration tool in aspen forests requires the availability of fuels and acceptance of the risk that accompanies the uncertainty of applying treatment. It is usually difficult to get a fire to carry through a pure aspen stand, even in the understory. Because of this, aspen stands are often used as living fire breaks. Elevated crowns and green understories restrict prescribed burning in pure aspen stands to narrow time periods in the spring and fall when vegetation is dry, but not covered with snow. Wildfires in aspen are most likely to occur in early spring before green-up. Thin-barked aspen stems are extremely sensitive to heat damage, so fire can be highly effective in stimulating aspen regeneration, if a burn of sufficient severity and ground coverage can be obtained (Brown and DeByle 1989).

Burning mixed aspen/conifer stands to regenerate aspen brings risks associated with an overabundance of fuels. Dense conifer understories, heavy loadings of downed logs, and continuous ladder fuels to the upper canopy usually require a prescribed crown fire to meet the requirements of the aspen regeneration triangle. Such fires can be quite effective and very spectacular, but may be damaging to aspen roots if the heat penetrates into the soil (Perala 1991). One means of mitigating this risk is to use prescribed fire as a secondary or site preparation tool in conjunction with harvest or mechanical manipulation to remove excess biomass. Fuels can be manipulated by the initial treatment to allow safe and effective burning later. Combining fire with other manipulation treatments can greatly benefit the aspen regeneration triangle, maximize suckering, and closely mimic natural fire disturbance cycles in mixed aspen/conifer ecosystems. We are currently testing the use of prescribed fire in combination with the harvest of competing overstory conifers in a cooperative study with the Coconino National Forest in Arizona. Fueled by the scattered logging slash, a subsequent prescribed burn stimulated much more suckering than did the removal of competing overstory conifers alone (figures 4, 5).

Mechanical Root Stimulation

Regenerating aspen by mechanical removal of overstory stems can produce successful aspen regeneration (Shepperd 1996; Perala 1991). Severing aspen roots from parent stems is also known to produce aspen suckers (Perala 1991). In a replicated study comparing bulldozing with chainsaw felling, Shepperd (1996) found that portions of clones where aspen was tipped over with a bulldozer produced significantly more sprouts than portions felled with a chainsaw. The difference was attributed the removal of stumps, which isolated lateral roots depriving them of any residual auxin left in the stumps. If true, it should be possible to initiate suckering in clones by mechanically severing some of the lateral roots. We currently are testing this stimulation effect at two sites in Arizona using a single-pass tractor-ripping technique (figure 6). The idea was to cut lateral roots spreading away from existing living stems, thereby interrupting the flow of auxin to bud primordia on the roots allowing the buds to sprout. So far, the two test clones have responded well. A map of sprout densities from a small, isolated, clone that was edge-ripped shows that the single ripper pass stimulated suckering about 20 m into the adjoining meadow at a density equivalent to 26,000+ stems/ha (figure 7). This one-time treatment effectively tripled the size of this small aspen clone without sacrificing any existing mature stems. None of the mature trees have died in the 5 years since the ripping treatment.

Pine removal/Slash burn

After pine harvest **After burn** **5 years later**

Figure 4—Pine removal and slash burn. The pine overstory was commercially harvested and then a light prescribed burn stimulated abundant aspen suckering. Coconino NF, Arizona.

Pine removal/No burn

After harvest of pine **5 years later**

Figure 5—Pine removal (a) and no burn (b). When the pine overstory was removed without subsequent slash burning, fewer suckers were produced than in the stand in figure 4.

Figure 6—Severing lateral aspen roots using a dozer-mounted ripper, Coconino NF, Arizona.

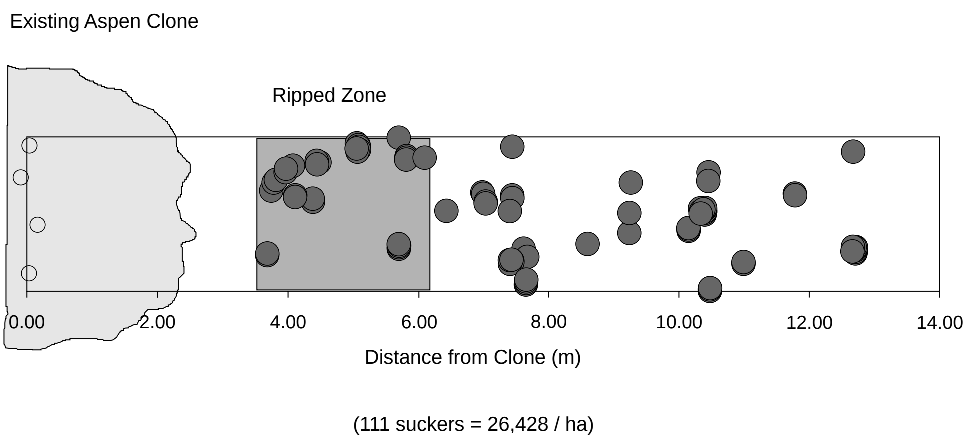

Figure 7—Mapped transect measured into a meadow adjoining an edge-ripped aspen clone. Circles represent locations of individual aspen suckers. Note clustering of suckers at root nodes, thus not all dots are visible.

Mechanical root stimulation may therefore be a cost effective tool useful to expand or rejuvenate small isolated clones where retention of existing mature aspen trees is highly desired. Full sunlight and warmer soil temperatures are still required at the location of the lateral roots being severed, so root stimulation should be limited to clones adjoining meadows, created openings, or in very open deteriorating clones (that are free of root disease). The limited size of most clones that can be treated in this manner will usually require protecting the new suckers from browsing animals until the suckers are established. Disking to stimulate aspen suckering is not recommended, however. The excessive mechanical disturbance to aspen roots can be detrimental to sucker survival and cause internal decay (Basham 1988; Perala 1977). The benefits of combining root stimulation with other treatments, such as clearfelling or burning, have not yet been tested.

Removal of Competing Vegetation

One thing that can be done to help a struggling clone to regenerate is to remove the vegetation that is inhibiting the process by shading or smothering young suckers. Vegetation removal can be done alone or in conjunction with other manipulations to increase initial suckering and slow or set back the rate of vegetative succession in aspen forests. It can include removal of competing overstory or understory vegetation as well as reduction of fuel loadings on the forest floor. Removal of competing vegetation can be accomplished with commercial timber harvest, mechanical treatment, prescribed fire, and chemical treatment via herbicides (Perala 1991). Removing vegetation meets only one of the three aspen regeneration triangle criteria by allowing sunlight to reach the forest floor and improving the growth environment for aspen. It does not directly stimulate sucker production or protect new suckers. However, it can have a dramatic effect, as happened in a small demonstration we installed on the Kaibab NF in Arizona. (figure 8). Removing competing pine from around the only two surviving aspen trees in this clone allowed the surrounding roots to sucker and expanded the clone to 0.1 ha in size. Fencing was required to protect sprouts from browsing animals, but the stimulation effect was readily apparent.

Protection of Regeneration From Herbivory

Protecting new aspen suckers from damage is an important consideration, regardless of the manipulation technique being used. A thorough assessment of the potential for damage should be conducted as part of any aspen management activity (including the do-nothing alternative) to determine whether new

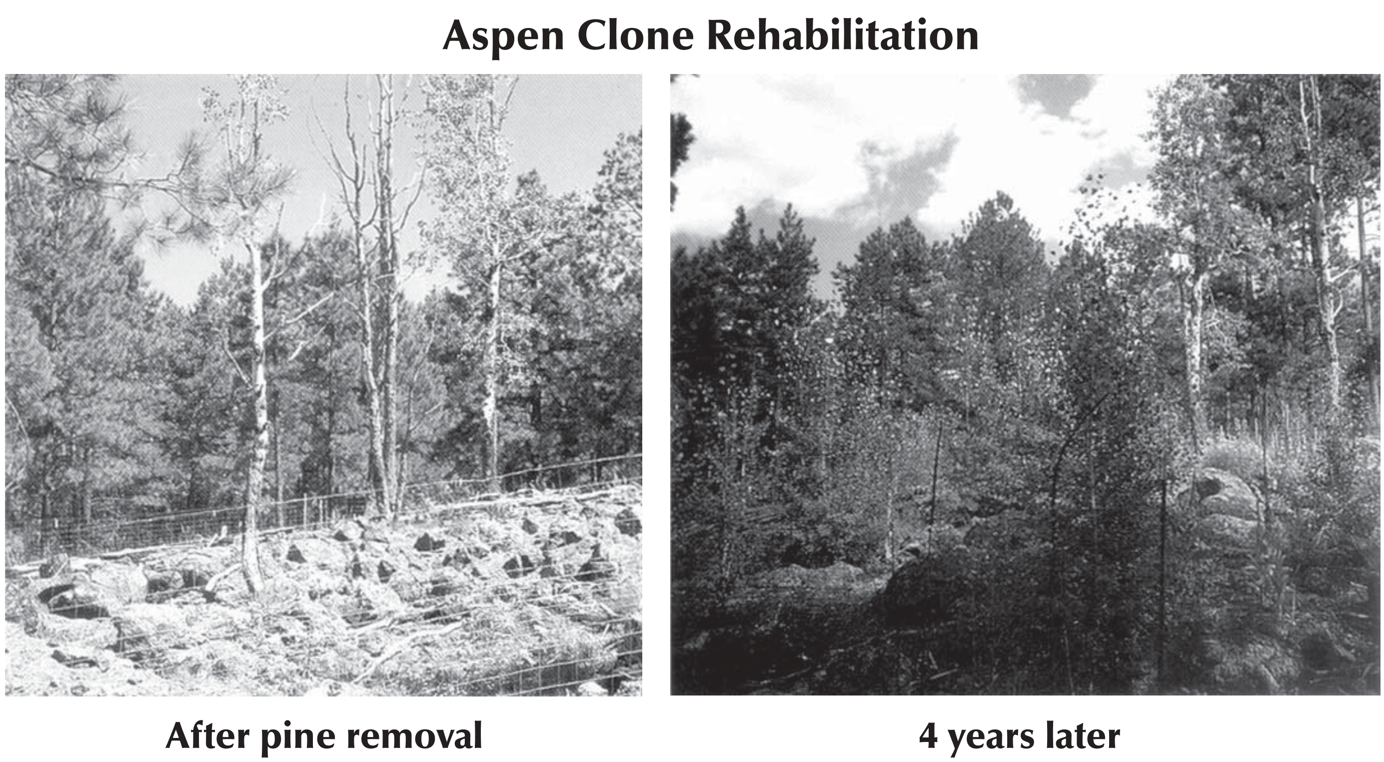

Figure 8—Aspen clone rehabilitation. Removal of a competing pine overstory allowed this two-stem aspen clone to sucker throughout a 0.1 ha area. Fencing assured survival of the new regeneration. Kaibab NF, Arizona.

suckers need to be protected from browsing animals. Getting aspen to sucker usually isn't the problem when manipulating aspen. Even declining aspen clones will sucker if conditions exist or are provided. Keeping sufficient numbers of suckers alive to accommodate natural sucker mortality (Shepperd 1996) and still restock the clone is often the real issue. This can be accomplished by either satiating the demand for sprouts (for example, providing more aspen suckers than all the animals within walking distance can eat), or by directly protecting the new aspen from browsing animals. Satiating the demand is easy if large acreages of aspen are treated. Experience in Colorado has shown that harvesting a number of large (6-8 ha) clearfell units at one time in a landscape will result in successful aspen regeneration without undue browsing damage, even when large numbers of animals were present (Crouch 1983).

Leaving logging slash has been reported to serve as a physical barrier to protect aspen sprouts from browsing (Rumble and others 1996), but slash appeared to inhibit suckering in another study (Shepperd 1996). The reasons for this discrepancy may be the amount and density of material that is left on site, or the inherent ability of some aspen genotypes to sucker in partially shaded conditions.

A recent experiment testing browse repellents on aspen under controlled field conditions demonstrated that elk browsing was significantly reduced under high repellent concentrations (Baker and others 1999). The cost of repeatedly applying repellents would likely be prohibitive under most wildland management situations, but repellents may be useful in deterring browsing in landscape plantings or other intensive cultures of aspen. Further testing of this technique is needed.

Fencing is the only guaranteed means of directly protecting sprouts from browsing animals. Constructing game-proof fences is a costly, labor intensive, time consuming, and long-term activity. Research (Shepperd and Fairweather 1994) and extensive management experience on the Coconino NF (Rolf, this proceedings) have shown that fencing is operationally feasible but must be maintained 8–10 years (or until dominant stems are 3 cm d.b.h.) to effectively protect aspen regeneration from high populations of elk. Wire fences constructed from two widths of 1 m wide field fencing, or one height of 1.4 m wide fencing with one or two high tensile smooth wires strung above, have been found to be effective. Electric fences have not proven effective, because of high maintenance requirements (Rolf, this proceedings).

Regenerating Aspen From Seed

Recent reports (including one in this proceedings) have demonstrated conclusively that aspen can occasionally reproduce naturally from seed in the western United States. However, given the stringent requirements of a bare mineral seedbed and ample supply of moisture needed to establish aspen seedlings (McDonough 1979), it seems unlikely that we can rely upon natural seedling regeneration or planting of artificially produced seedlings in most wildland management situations. We have established a research plantation of containerized aspen in a riparian area on the Arapaho National Forest to test the possibility of restoring aspen to areas with abundant soil moisture. Two-year survival is less than 50%, and seedling growth has been poor. Although not encouraging, these results do indicate that it may be possible to reestablish aspen in an area where it has been lost. Research using larger-sized transplant stock is needed to further test the feasibility of reestablishing aspen in critical areas.

Conclusions

Several options exist to manipulate existing aspen clones to stimulate vegetative regeneration. Success of any manipulation method depends upon taking advantage of aspen's silvical and growth characteristics to provide the correct combination of factors to initiate root suckering and to ensure maximum growth and survival of the new aspen. Manipulation should stimulate roots to sucker, provide optimal growth conditions for the new regeneration, and protect new suckers from browsing animals. The aspen regeneration triangle provides an easy means of visualizing these three key factors.

Choosing the correct course of action to provide these elements depends upon a careful evaluation of existing conditions. Size, vigor, age, and health of the existing aspen clone, soils and site productivity, competition from other tree and understory species, and the potential impact of browsing animals upon new regeneration should all be considered. Success also depends upon careful monitoring of treatment results and adapting future activities to fit local conditions.

Decisions to manipulate aspen also need to be based on the role it plays in the surrounding landscape. Basing management decisions on the current condition of an individual clone may be insufficient to meet ecosystem needs. The need for age class and structural diversity in the overall landscape, as well as the need to maintain desired resource outputs (timber, forage, wildlife habitat, visuals, and so on), should be factored into the decision. No single manipulation prescription can be expected to work under the continent-wide diversity of conditions where aspen is found.

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