Landscape Dynamics of Aspen and Conifer Forests

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Abstract—*Quaking aspen (*Populus tremuloides *Michx.) is widely dispersed across the landscape of North America. Seventy-five percent of the aspen in the western United States occurs in the states of Colorado (50%) and Utah (25%). Reproduction in aspen is primarily by asexual means, e.g., root sprouts that are generally referred to as suckers. An aspen clone consists of numerous stems that are genetically alike that began from a single seed that germinated sometime in the past. Generally, these clones have been perpetuated on site by disturbance that allowed the clones to survive and expand in the area. The importance of aspen in the Interior West is well described and documented in the literature. Besides adding diversity to the landscape, aspen also provides water, forage, wood products, and so on for use by the public. Since European settlement, the natural disturbance regime (usually fire) has been interrupted. This has caused much of the aspen-dominated lands to succeed to conifers. The decline in aspen ranges from 49% in Colorado to 95% in Arizona. Numerous techniques are available to aid the manager in restoring aspen to a level approaching its historical occurrence.*

I have studied quaking aspen (*Populus tremuloides* Michx.) for the past 28 years for Forest Service Research. Early in my career I studied the vegetative responses of aspen systems to various types of disturbances (burning, cutting, spraying, and so on). More recently, I have been involved primarily in technology transfer of knowledge about the functioning and restoration of aspen in the Intermountain West. During this time, there has been a marked increase in public awareness and concern regarding aspen lands, resulting in an urgency, in some areas, for restoring aspen on the landscape.

Introduction

Quaking aspen is the most widely distributed deciduous tree in North America (Little 1971; Sargent 1890). It occurs from the east coast to Alaska in the north and then runs down through the Rocky Mountains (figure 1). In the western United States, aspen occurs on mountainous and high plateaus (Jones 1985); on xeric sites it occurs primarily in riparian zones. Almost 75% of the western aspen occurs in Colorado and Utah.

Aspen Condition Types

Western aspen exist in primarily three different types (Bartos and Campbell 1998a): (1) stable, (2) successional to conifers, and (3) decadent and falling apart.

Stable aspen is considered to be "properly functioning" and replacing itself. In many instances, these clones exist with a "skirt" or "fairy ring" of young regeneration around the edge and numerous sized stems in the interior (figure 2). The stems are of various ages that resulted from pulses of regeneration that

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Figure 1—Map showing the potential distribution of quaking aspen for North America (Little 1971).

occurred at various times in the past. Generally, an individual standing near a stable clone has difficulty seeing into or through it.

Aspen succeeding to conifers are responding to natural forces. Aspen is considered a disturbance species perpetuated on site by fire, disease, or other such occurrences. Some of these forces (primarily fire) have been altered by human intervention, which has given shade-tolerant conifers a marked advantage. We see numerous situations where aspen are being replaced by less desirable vegetation types such as subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) (figure 3) or sagebrush (*Artemisia* spp.). In turn, these type conversions are modifying the sites dramatically. In most areas of the West, these modified aspen clones should be given top priority for restoration.

Decadent clones are generally of a single age and are very open; mature trees are not being replaced as they die because successful regeneration is lacking (figure 4). Most of these clones attempt to reproduce, but the new shoots are consumed primarily by wild or domestic ungulates. Clonal vigor is reduced as these regeneration events occur year after year. Fewer and fewer suckers are

Figure 2—Stable (properly functioning) aspen that has a "skirt" or "fairy ring" of regeneration.

Figure 3—Conifer-dominated aspen that accounts for a great deal of the decline of aspen in the western United States.

Figure 4—Decadent aspen that has overmature stems and little or no regeneration. These sites will be replaced by sagebrush or other tall shrubs if treatment is not imposed.

produced and in some areas the old clones are lost from the system. A person standing near a decadent clone can see into or through the clone.

Reproduction

An aspen clone contains numerous genetically identical stems (ramets) that propagated vegetatively from a single seedling that became established at some time in the past. These aspen stems originate from root suckers, some of which still may be interconnected via the root system. Shepperd and Smith (1993) reported that aspen stems establish independent root systems by approximately 25 years of age, with few mature stems still connected by the original root system. These self-regenerating clones have existed for thousands of years according to Barnes (1975), being perpetuated over time by disturbance. These clones usually expanded during this time and, therefore, some occupy large areas. Kemperman and Barnes (1976) report clones as large as 200 acres (81 hectares).

Successful sexual reproduction of western aspen is extremely rare (Mitton and Grant 1996). Jelinski and Cheliak (1992) describe a "window of opportunity" that may allow seedling establishment at intervals of 200–400 years. Therefore, unlike other western tree species, aspen once lost from the landscape generally will not reestablish from seed in the Intermountain West.

Vegetative reproduction by suckers generally requires a disturbance or dieback that alters the hormonal balance within the system (Schier et al. 1985; Bancroft 1989). The flow of two hormones (cytokinin and auxin) within an aspen tree are shown in figure 5 (Bancroft 1989). Basically, when the tree is killed or stressed, the flow of sucker-suppressing auxins from the crown down to the root system is disrupted, which allows cytokinin to stimulate suckering.

In areas where there is extensive ungulate pressure (both domestic and wildlife), however, treatment alone to induce aspen suckering is not enough. Such actions must not be initiated before relief from excessive browsing is obtained (Southwest Region 1994).

Values

Products and benefits derived from the aspen ecosystem are varied and numerous (Bartos and Campbell 1998a,b; DeByle and Winokur 1985). Values attributed to the western aspen system include, but are not limited to, forage for livestock, habitat for wildlife, water for downstream users, esthetics, recreational sites, wood fiber, and landscape diversity. When the aspen system is not functioning properly, many of these values are compromised. Bartos and Campbell (1998b) describe the loss of water, forage, biodiversity, and other benefits when aspen-dominated landscapes are lost.

Generally, when conifers replace aspen there is a potential for a decrease in water yields. Harper et al. (1981) reported a decrease of 5% and Gifford et al. (1984) predicted a decrease of from 3 to 7 inches in water yields when conifers replace aspen. This loss of water means that it is not available to produce undergrowth vegetation, recharge soil profiles, or increase streamflow. In dry climates, such as the Great Basin, this loss of water is substantial and should be of great concern to the public.

Undergrowth vegetation associated with aspen forests is generally considered prime grazing for domestic livestock. When conifers replace aspen there is a marked decline in forage production. Mueggler (1988) reported that aspen

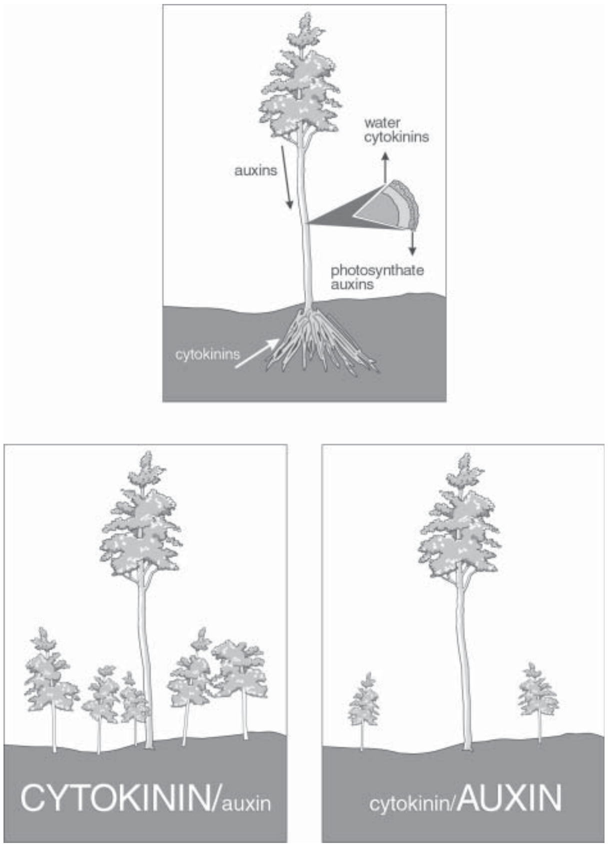

Figure 5—Representation of the flow of hormones (cytokinin/auxin) within an aspen tree and the ratio of hormones' effect on suckering (Bancroft 1989).

communities can produce as much as 3,200 kg/ha (2,900 lb/ac) of air-dry undergrowth material and averaged 1,350 kg/ha (1,200 lb/ac). On the Wasatch Plateau of Utah, undergrowth production can be reduced by 50% when conifers make up as little as 15% of the total tree basal area (Mueggler 1985). In another study, Mueggler (1988) observed that undergrowth production was reduced 67% when conifers made up 15% of the total tree basal area. Once conifer invasion approaches 50% of the total tree basal area in aspen stands, undergrowth production is only a small fraction of what it once was on these formerly excellent grazing lands. In areas where there has been considerable loss of aspen, this dramatic change in forage production should be considered when determining stocking rates.

Aspen-dominated sites are considered to be high in biodiversity—second only to riparian areas on western sites (Kay 1997). When aspen lands change to either conifer or sagebrush dominance, marked changes in both flora and fauna occur. Not only is there a loss of forage production as detailed above, but there is a substantial decrease in plant species richness when there is a loss of aspen. Bartos and Mitchell (2000) synthesized numerous articles from the Rocky Mountain area and found that there were ~29 undergrowth species under aspen compared to only 19 species associated with subalpine fire, lodgepole pine (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*). Winternitz (1980) reported that the density and diversity of birds was greater in aspen than conifer stands and McGraw/Bergstrom (1986) observed that mature aspen stands contained more bird species than younger stands or those being invaded by conifers. Bird species diversity also increases with the size of aspen stands (Johns 1993). Other examples of changes in species biodiversity that are not often considered include lichens, bats, and snails (Bartos and Mitchell 2000).

Aspen is portrayed as an excellent indicator of ecological integrity as well as landscape health (Kay 1991a,b; Woodley and Theberge 1992; Woodley 1993; Woodley et al. 1993).

Some consider aspen a keystone species (e.g., "the removal of a keystone species causes a substantial part of the community to change drastically" [Wilson 1992]). Houston (1954) noted that aspen reproduction has long been used as an indicator of range condition. Thus, the importance of aspen on the western landscape cannot be over emphasized.

Decline of Aspen

Repeat photos are one way to evaluate changes on the landscape, especially with the loss of aspen. Locations in historical prints are rephotographed from the same photopoint, thus forming a pair of photos. These photos provide a visual example of the magnitude of the decline of aspen over time. Numerous pairs of photos have been obtained from southern Utah with the originals taken in the late 1800s or early 1900s. Figure 6 shows an example; the change in vegetation is readily apparent.

The Rocky Mountain Research Station's Forest Inventory and Analysis Project (FIA) has collected data on the current and historical acreage of aspen in the Interior West. The historical data are a result of summing all acres that currently contain at least one aspen either living or dead; this assumes that this acreage is, or once was, occupied by aspen. FIA data obtained from National Forest Systems land for the state of Utah shows at least a 60% decrease in aspen domination since the arrival of Europeans (table 1) (Bartos and Campbell 1998a). Similar trends (50–96% decline) have been observed throughout the western United States (table 2) (Bartos and Mitchell 2000).

Similar figures have been reported elsewhere for the West. Using remote sensing and geographic information systems (GIS), Lachowski and others (1996) and Wirth and others (1996) evaluated the loss of aspen in the Gravelly Mountains in southwestern Montana. They found a ~47% decrease in aspen from 1947 to 1992 and attributed most of that change to conifer invasion. In a review article, Brown (1995) found decline values for Oregon and Washington that were very similar to those reported here.

Figure 6—Repeat photographs (1872–1996) from Bee Lake, Fishlake National Forest. Repeat photos and interpretation provided by Dr. Charles Kay, Adjunct Assistant Professor, Department of Political Science, Utah State University, Logan, Utah.

Table 1—Current and historical acres of aspen found in Utah. (Unpublished data provided by the Rocky Mountain Research Station's Forest Inventory and Analysis Project.)

Area	Current aspen	Historical aspen	Decline
	- - - - - - - - - - *Acres* - - - - - - - - -		*Percent*
Ashley National Forest	101,358	322,532	69
Uinta National Forest	174,492	285,351	29
Wasatch-Cache National Forest	128,615	373,837	66
Dixie National Forest	153,053	437,715	65
Fishlake National Forest	141,948	313,724	55
Manti-LaSal National Forest	158,866	338,008	53
Southern Utah	453,867	1,089,447	58
Northern Utah	404,465	981,720	59
Total National Forest in Utah	858,332	2,071,167	59

Table 2—Current and historical acres of aspen in the Interior West. (Unpublished data provided by the Rocky Mountain Research Station's Forest Inventory and Analysis Project.)

Area	Current aspen	Historical aspen	Decline
	- - - - - - - - - - - *Acres* - - - - - - - - - -		*Percent*
Colorado	1,110,764	2,188,003	49
Utah	1,427,973	2,930,684	51
New Mexico	140,227	1,141,677	88
Wyoming	203,965	436,460	53
Arizona	29,009	720,880	96
Idaho	621,520	1,609,547	61
Montana	211,046	590,674	64
Nevada	118,768	———	
Total	3,863,272	9,617,925	60

Conclusions

The following conclusions can be made regarding the current situation of aspen in the western United States:

1. Aspen is the most widely distributed deciduous tree in North America; it usually needs disturbance to perpetuate itself in the West.
2. Aspen clones consist of numerous stems (ramets) that are genetically alike and these clones have been perpetuated over time, primarily by fire.
3. Numerous products are produced by the aspen type, on which the public has placed high value.
4. Aspen exists in three broad categories: (1) stable and regenerating, (2) converting to conifers, and (3) decadent and deteriorating.
5. Recent data shows that aspen in the western United States has declined 50–96%.
6. Currently, there is considerable interest in restoring aspen to a level that existed prior to European settlement.
7. Numerous techniques (e.g., burning, cutting, spraying, chaining, and ripping) exist for use in restoring aspen. These techniques are covered elsewhere in this proceedings.
8. Before treatments are applied, excessive animal use must be addressed so that aspen regeneration can escape destructive browsing.

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