Section 4: Science and Ecology of Quaking Aspen

This section offers an introduction to the ecology of quaking aspen. Many scientific citations are included, and this section should provide support for those committees wanting to get further into the science of aspen to support their restoration efforts.

Ecology of Aspen

Quaking aspen is the most widespread hardwood tree species in North America, and of particular importance to land managers in the Intermountain West (Shepperd et al. 2001). In central and eastern Oregon, aspen is one of the only hardwood tree species that is found outside of riparian areas. Aspen is shade intolerant, primarily reproduces through clonal root sprouting (suckering), and is moisture demanding even as it grows across dry and moist forested landscapes. This makes aspen susceptible to drought where individual trees or entire stands might be lost (Hogg et al. 2008, Worral et al. 2010). Aspen evolved on fire-prone landscapes and is fire adapted. Fire removes competing conifer trees, kills mature aspen stems, stimulates root-sprouting, and increases moisture and forage at the landscape level which disperses herbivores (Seager et al. 2013b, Shinneman et al. 2013). Additionally fire creates bare mineral soil that is needed for aspen seed to successfully germinate.

In the drylands and forests of the Intermountain West, aspen provide a disproportionate amount of habitat for wildlife (DeByle 1985, White et al. 1998). Aspen and the associated plant communities (aspen ecosystems) support diverse biota across multiple food webs. These ecosystems are biodiversity hotspots for small mammals (Oaten and Larsen 2009), songbirds, and primary and secondary cavity nesters (Martin et al. 2004). The rich understory provides increase forage for livestock and wild ungulates, with aspen sprouts being preferred browse species for elk and deer during fall and winter. Chronic and excessive browsing of sprouts can suppress recruitment of aspen into overstory trees, leading to stand decline and eventual loss (Swanson et al. 2010, Seager et al. 2013b).

Aspen can reproduce vegetatively, where buds form on the roots and sprout, forming clonal suckers (or aspen sprouts) that are genetically identical to the parent tree. These aspen sprouts can appear as far out as the parental root system reaches. The aspen sprouts are connected to the parental root system, allowing them to grow quickly. While originally thought to be rare, research now shows that aspen trees produce seed regularly. Both the pollen and the seed can travel long distances on wind, allowing aspen seedlings to establish multiple miles from any source (Long and Mock 2011). Unless genetic testing is done, nearby aspen stands cannot be assumed to be identical clones or related. A study on the Umatilla National Forest in the Blue Mountains found that while most stands were a single clone, others were made up of multiple clones (Shirley and Ericson 2001).

Drivers and Suppressors of Aspen Regeneration and Growth

Aspen sprouting (root suckering) can be initiated by many complex interactions with the environment and the parent tree. Different drivers may be occurring in different stands depending on the limiting factors.

A review of Oregon aspen studies found the most successful driver of aspen in Oregon has been (1) **removal of competing conifers** and (2) **release from herbivory** (Seager et al. 2013a, Table 1.0). While the science gives support and specific details for restoration, most land managers have been practicing this 1-2 approach for decades (Shirley and Ericson 2001, Strong et al. 2010, Swanson et al. 2010). Since conifer removal represents a release of moisture, light, and nutrients all at one time, it is challenging to know which one had the greatest effect. Additionally, it is important to remember that aspen growth and survival may be driven by genetics (Lindroth and St. Clair 2013). Here we provide a list of drivers and suppressors of aspen along with a brief explanation and scientific context.

Moisture – the deep soils in some aspen stands can hold snowmelt moisture into the summer months. This allows increased sprouting and overstory growth. By contrast, drier parts of the stand or stands with more shallow soils will face moisture limitation, which can be exacerbated when competing with encroaching conifers. Aspen need moisture late into the growing season (August), and can be limited in growth and sprouting. Release of moisture by encroaching conifers has been shown to increase aspen sprout density and persistence of overstory (Shirley and Ericson 2001, Jones et al. 2005, Swanson et al. 2010, Seager et al. 2013a). Normal and high precipitation years are not as much of a concern as periodic or multi-year droughts. Restoration planning should include aspen moisture needs during dry years.

Light – aspen are shade intolerant. Conifer shading decreases sprout density, sprout survival, and can kill mature aspen by overtopping them (Jones et al. 2005, Seager 2010). An increase in light through conifer removal can stimulate suckering and reinvigorate aspen overstory (Jones et al. 2005). Light is more of a limiting factor in dense dry mixed conifer and cool moist conifer forest types, whereas moisture is the limiting factor in hot dry and warm dry forests.

Chronic Herbivory – high densities of aspen suckering can tolerate browsing pressure from livestock and wild ungulates (Swanson et al. 2010). However, chronic herbivory (high levels across multiple years) suppresses aspen sprouts, increases disease and stress, and may remove the midstory and future overstory cohorts of aspen trees. Release from herbivory through fencing, jackstraw, alternate grazing patterns, removal of livestock, or other herbivory deterrents can effectively release aspen sprouts even after years of suppression (Seager et al. 2013a). Research shows that different herbivory deterrents may be effective on different landscapes, giving managers multiple options to choose from, including fencing, jackstraw, alternate grazing patterns, removal of livestock, deer and elk herd management, among others (Seager et al. 2013b).

Disturbance – moderate soil disturbance from conifer removal and logging activity can stimulate higher levels of aspen root sprouting. Natural disturbances such as late frost, leaf defoliators, or other impacts on aspen overstory can also stimulate high-density root sprouting. The complete removal of the aspen overstory, known as clear-fell coppicing, releases all lateral roots to sprout (Shepperd 2001) including in stands that have already faced severe drought and dieback (Shepperd et al. 2015). Fire, even low severity, causes the greatest density of root sprouting (Shinneman et al. 2013). Restoration of Oregon's eastside forests may include multiple disturbance activities (Franklin et al. 2013). Increased aspen sprout density can attract more herbivores. A northeast Oregon study found that removal of conifers, fire, or soil disturbance activities may need to be followed by fencing or other deterrents to assure sufficient aspen recruitment (Endress et al. 2012)

Temperature – new research shows that temperature doesn't play as important a role in increasing sprout density as was previously thought (Frey et al. 2003). However, temperature does play a key role in helping aspen sprouts grow to gain height. Stands with warmer temperature (access to sunlight through decreased conifer overstory) have sprouts that grow sooner and grow taller during the season (Frey et al. 2003). Conifer shading decreases sprout density, sprout growth, and soil temperatures (Wall et al. 2001).

Aspen in the Oregon East Cascades and Blue Mountains

Although widespread across central and eastern Oregon, aspen accounts for less than 1% of all forested lands, though may be up to 5% of forested areas within specific projects (Swanson et al. 2010). These small aspen stands in Oregon are quite different from the aspen stands found in the Rocky Mountain Region, where they can grow as extensive parklands and montane forests.

In the Rockies, aspen can grow as large forests on mountainsides, fed by annual snowpack and summer rain. In that environment, aspen can compete against conifers in establishing as forest

Colorado Aspen Forest

Aspen forest covering the hillside on Grand Mesa, Colorado. Note: (1) the dead patches of aspen from drought show how densely the stands are stocked; and (2) the conifer trees make up less than 10% of the aspen forest and are in the high moisture drainage. Photo: Trent Seager.

Oregon Aspen Stand

Aspen stand (small patch) after treatment of conifer removal on the Deschutes National Forest (Crescent Ranger District). Note: (1) even with the stand expanding, it is still less than one-quarter of an acre; and (2) the aspen are growing in the swale, where the soil is deeper and has more moisture. This is typical of aspen in Oregon, and very different from the Colorado photo above. Photo: Trent Seager.

types, and do so as seral stands regenerating after stand replacing fire events and stable stands that persist without disturbance (Rogers et al. 2013).

In Oregon, aspen primarily grow in small patches near seeps and water sources, usually with deep soil. These stands sprout annually even without fire, yet remain as small patches and not forest-types (see comparison photos above). Due to this difference, forest collaborative groups, the Forest Service and other partners in Oregon should use caution when applying silviculture prescriptions or research findings from other Intermountain Regions (e.g., the Rocky Mountains) if their findings are tied to biophysical settings different from those found on the eastside of Oregon (see Seager et al. 2013a).

Small, Discrete Stands

Throughout the forests of central Oregon and the Blue Mountains, aspen primarily occur as small (< 1 acre), discrete stands associated with meadows or within a conifer forest matrix. Aspen in Oregon can occasionally exist as large, pure stands such as those found on Steens Mountain, as widespread mixed stands such as those found in Baker County, or as extensive stands connected through large meadow systems as those found in the Klamath Basin (Seager 2010, Swanson et al. 2010, Seager et al. 2013a). These are the exception in Oregon, and most National Forests are managing small, isolated aspen stands.

It is important to note that on the Malheur, Umatilla, Wallowa-Whitman, and Deschutes National Forests only 1-5% of all aspen stands are >10 acres, and they contain low aspen basal area (Seager 2010, Swanson et al. 2010).

Historical Conditions

It is difficult to document the historical condition of aspen on the landscape because it is such a short-lived tree species (<150 years). Additionally, most of central and eastern Oregon has a history of fire suppression (Agee 1993, Franklin et al. 2013) and wild ungulate irruptions (exponential growth in population) during the first half of the twentieth century (Leopold et al. 1947, Salwasser 1979, Peek et al. 2001, Seager et al. 2013b), which altered aspen regeneration and recruitment. Historical photos that identify placement and extent should help guide landscape level restoration. With on-going changes in precipitation and summer temperatures (global climate change), the focus should be on desired conditions and resiliency rather than restoring to historical or current conditions.

Local Forest Service offices may have maps and information on aspen stand locations, extent, size, and condition across the decades. Additionally, Forest Service technical reports and papers may contain information to help collaborative groups better understand aspen stand conditions from 20-30 years ago (Kovalchik 1987).

Current Condition and Need: Extensive Loss in Oregon

Multiple studies on aspen across diverse forest types in Oregon have found that aspen have declined in extent (overall acreage) and spatially (locations) across diverse landscapes (Wall et al. 2001, Shirley and Erickson 2001, Bates et al. 2006, Swanson et al. 2010, Seager 2010, Seager et al. 2013a). Research from the Rocky Mountain region shows that aspen loss can vary greatly spatially and temporally, with some landscapes showing an increase or stable amounts of aspen cover while others show greater loss (Kulakowski et al. 2013). The loss of aspen in the west has varying estimates, with Oregon's loss being estimated to be 50-80% in some areas (Seager 2010, Swanson et al. 2010, Seager et al. 2013a), with recent loss of 25% of aspen cover that was present in the 1940s (Di Orio et al. 2005) and 95% of remaining stands showing encroachment by conifers (Sankey 2009). Restoration of aspen in Oregon that began twenty years ago noted that loss was occurring at a rapid rate (Shirley and Erickson 2001). Future predictions show loss of Oregon's current aspen cover by more than 90% by 2030 (Rehfeldt et al. 2009). Land managers and scientists are in agreement that loss of aspen in Oregon's eastside has been significant, and its restoration should be prioritized (Swanson et al. 2010, Franklin et al. 2013, Seager et al. 2013a).

Aspen in Landscape-level Disturbance

When landscape level disturbance (fire, logging, understory thinning) occurs in a dry forest ecosystem that is out of its historical range of variability, there can be an increase in natural processes that include: water retention, nutrient release and cycling, and biomass production (Agee 2003, Keane et al. 2009). This larger scale forest or landscape-level disturbance can help aspen by:

- dispersing livestock and wild ungulates through increased forage
- releasing more moisture during spring snowmelt to be captured in the deep soils of the aspen stands
- decreasing conifer competition for light, moisture, and soil resources in and around aspen stands (Smith et al. 2011)

If restoration efforts for Oregon's eastside forest are to help restore different dry forest ecosystems (e.g., dry pine, dry mixed conifer, moist mixed conifer) to a more resilience state of structure, patterns, and disturbance regimes (Franklin et al. 2013), land managers and associated collaborative groups should consider the role those efforts can play in helping restore aspen to a more resilient state especially at a landscape scale (Seager et al. 2013a).