ASPEN ECOLOGY AND MANAGEMENT: THE FOUNDATION FOR PLANNING INTO THE FUTURE

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Abstract

Aspen, the most widely distributed tree species in North America is a vital component of almost every forest ecosystem in western North America, providing vegetation diversity, wildlife habitat, livestock forage, specialty forest products, and highly desirable scenery. Aspen's ability to grow in full sunlight and vegetatively regenerate via root suckering allows it to thrive following fire, or other disturbance. Although aspen is susceptible to many diseases and damaging agents, it persists through periodic natural regeneration episodes driven by disturbance. Deteriorating aspen stands result when this natural cycle of renewal is interrupted, as has happened with wildfire suppression and excessive utilization of young aspen by browsing animals. The aspen regeneration triangle, representing the critical factors of hormonal stimulation, proper growth environment, and protection of new regeneration can serve as a useful guide in planning management actions in aspen forests.

Key Words: Aspen, *Populus tremuloides*, silviculture, management

Introduction

Aspen is an iconic species, highly valued for aesthetics, wildlife habitat, and forage resources of its diverse and productive understory. However, it is also an enigma. Aspen is dependent upon disturbance to regenerate, yet it is susceptible to other disturbances such as insects, diseases and herbivory that threaten its existence on some sites. As a species, aspen is tough and resilient and has existed for millennia in some locations, but individual trees and specific groves are quite susceptible to disease and competition from shade tolerant conifers. Understanding how these factors interact is key to developing management regimes for aspen on a specific site.

Management of aspen requires an appreciation of the species' unique ecologic characteristics and the conditions required to successfully establish a new generation of aspen on a specific site. The objective of this paper is to review these requirements and present specific management actions that can be used to restore aspen where it is in decline.

Two characteristics set aspen apart from other tree species that are typically managed in the western United States 1) It is extremely intolerant of shade and 2) it reproduces primarily by vegetative sprouting from the pre-existing roots of parent trees. Both of these characteristics give aspen a huge competitive advantage over other vegetation following intensive crown fires that typically occur in situations where aspen is growing in mixed stands with conifers. Although aspen trees are killed along with conifers in such fires, their extensive, spreading root systems remain largely intact. When aspen trees are stressed or die the interruption of an auxin hormone normally produced by healthy aspen trees stimulates pre-existing buds on near-surface aspen roots to grow into new young trees. The extensive pre-existing root system, plus the nutrient pulse from the fire and increased soil temperature resulting from solar warming of the blackened soil typically result in an explosion of rapidly growing aspen sprouts.

This rapid growth, coupled with the general absence of competing plants insures that aspen will dominate vegetation on burned sites for some time after a stand-replacing crown fire. During this period, aspen will support a lush and diverse understory that will provide habitat and forage for a wide variety of species. These lush understories along with the lack of ladder fuels will allow aspen stands to serve as natural fire breaks in landscapes until such time as conifers re-establish to sufficient sizes and densities to once again carry a crown fire and allow the cycle to repeat.

The Current Situation

This disturbance cycle has been active in North America for many millennia and is responsible for the extensive and diverse distribution of aspen in many western landscapes. However, other factors have been introduced since European settlement that have altered the aspen regeneration cycle and induced stresses in aspen that have resulted in its decline in many areas and disappearance in others. Lack of stand replacement crown fires have altered the age class distribution of aspen across many landscapes, skewing them toward older age classes and a greater presence of conifers in landscapes where aspen was once more abundant. Intensive grazing of aspen understories has further prevented new aspen cohorts from successfully establishing after other disturbances. Utilization of aspen sprouts and the bark of mature aspen by growing wild ungulate populations further contribute to aspen decline by introducing stem diseases that kill mature stems, but prevent re-establishment of new aspen cohorts. The combined effects of these stress factors result in a gradual weakening of aspen root systems as more trees die. Fewer and weaker roots result in fewer and weaker sprouts if a regeneration-producing disturbance does occur, which further contributes to the cycle of decline.

Successful management and restoration of aspen in western landscapes requires: 1) Recognition of stress factors affecting the health and vigor of aspen in a given locality, 2) Providing proper conditions to stimulate and favor new aspen regeneration and 3) Insuring that sufficient numbers of new sprouts survive to re-populate a vigorous aspen forest on the site. Specific managements actions needed to accomplish these goals vary, depending upon the health, vigor, successional status of a particular aspen stand and the stresses affecting it. Several proven tools are available to managers to help categorize aspen in landscapes, assess its vigor, and select a course of action to maintain or restore it. Burton (2004) developed a very successful protocol for monitoring and assessing the condition of aspen where it is a minor component of landscapes. Bartos and Campbell (1998) refining an earlier classification by Mueggler (1988) developed a handy key to identify aspen stands in need of regeneration. The aspen regeneration triangle (Shepperd 2001,2004, Shepperd et al. 2006) serves as a decision model to identify factors needed to successfully regenerate aspen by isolating the need to stimulate sprouting, provide growing conditions conducive to aspen, and protect sprouts once they occur (Fig. 1). These tools complement one another and can be used universally to plan aspen management activities in western landscapes.

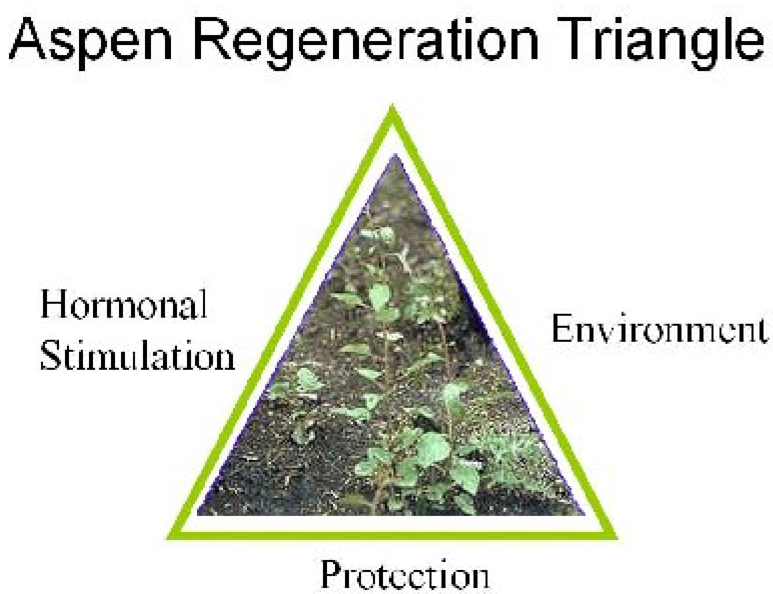

Figure 1. The aspen regeneration triangle model (Shepperd 2004)

Cultural practices applicable to aspen

Although aspen does produce viable seed and seedling regeneration has been documented (Kay 1993, Romme et al. 1997, Quinn and Wu 2001), vegetative regeneration is a much more reliable method to regenerate aspen. Planting aspen seedlings is extremely difficult and costly (Shepperd and Mata 2005) and not practical as a wildland management alternative. Aspen readily self-thins beginning immediately after sprouting occurs (Shepperd 1993). Intermediate thinning has not been definitively proven to benefit aspen growth (Jones and Shepperd 1985).

As outlined in the aspen regeneration triangle (Fig.1), successful aspen sprouting depends upon three key interacting components: hormonal stimulation, growth environment, and protection of the resulting sprouts. All three of these requirements must be met to successfully regenerate the species, but all three elements may not always need to be actively provided by managers. One or more of the elements could already exist in any particular aspen stand, so identifying which factors are lacking is crucial.

Maximum sprouting density of aspen is achieved by a clearfell harvest of all trees (Shepperd 1993) and is recommended where aspen is managed for commercial fiber production (Shepperd et al. 2006). However, other cultural activities are effective where the goal is to restore aspen, or introduce new age cohorts into existing aspen groves. These include removal of competing conifers, ripping to isolate roots and stimulate sprouting, use of prescribed fire to mimic natural fire regimes, or augment other treatments, and fencing to eliminate browsing of aspen. Specific research studies that tested these alternate regeneration methods are reported in Shepperd (2004) and will be reviewed briefly here.

Removing Competing Vegetation—Older aspen are often stressed and already trying to sprout, so the hormonal stimulation to regenerate already exists, especially in late successional aspen/conifer stands. Removing the conifers will allow sunlight to reach the forest floor and increase soil temperatures, which favors the growth of aspen sprouts. Creating holes in the conifer forest surrounding isolated pockets of residual aspen can allow aspen to expand into these areas as aspen roots already exist at least a tree height away from existing aspen trees (Shepperd 2001, 2004). Removal of competing conifers will enhance any natural sprout production that is already occurring in declining clones and can retain any remaining old aspen trees for aesthetic and wildlife purposes (Jones et al. 2005).

Protection from Browsing—If aspen sprouts already exist, but are heavily browsed and shrubby in appearance with no central growth axis, protection from browsing may be all that is needed to successfully re-establish the stand. Direct protection will likely be expensive, because of the cost of constructing fences (Rolf 2001, Kees 2004), but it may be the only way to successfully reestablish aspen in many areas where aspen is a minor component of forested landscapes and browsing animals are present. In addition to fencing, direct protection can also include manipulating logging slash, (Rumble et al. 1996) and "hinging" or partially felling aspen or conifer trees around the perimeter of clones (Kota 2005) to exclude browsing animals. Chemical browse repellents can be effective at high dosages (Baker et al. 1999), but are likely too expensive for most wildland applications.

The intent of protection is to prevent browsing of the terminal leader of the young aspen sprouts, which can lead to "hedging" or a shrubby growth form that will never develop into a tree. The length of time that sprouts need protection depends upon whether the browsers are domestic livestock or elk. Domestic livestock will usually not bother sprouts over 6 feet (2 m) in height, but elk can break off and consume aspen saplings up to 1.5 inches (4 cm) in diameter at breast height (4.5 feet or 1.4 m) (Shepperd 2004). In most cases eight to ten years of normal growth are necessary for sprouts to attain these sizes (Shepperd 2004).

Prescribed Fire—Aspen is a fire-adapted species, so prescribed fire can be used very effectively to regenerate aspen. Fire provides hormonal stimulation to initiate sprout production by killing overstory aspen trees and injuring lateral roots, which interrupts the flow of auxin. It also removes competing vegetation and blackens the soil surface, allowing it to be warmed by the sun to create ideal growing conditions for young aspen sprouts. Burning also releases nutrients that contribute to the growth of sprouts. Prescribed burning may not provide protection for the new sprouts, unless large enough areas of aspen can be burned to satiate browsing animals.

Fuel loadings in pure aspen forests are generally light and the lush understory vegetation usually has high moisture content and does not contain sufficient biomass to burn effectively (Fechner and Barrows 1976). Burning to regenerate aspen in these stands requires timing the fire when fuels are dry or using alternative fuels to carry the fire into the aspen (for example burning adjacent shrublands) (Shepperd 2004). Although such burns may not kill all aspen trees they usually burn far enough into the aspen to stimulate new sprouts along the edges of groves. This can result in a diverse landscape containing new sprout stands, mixed-aged groves, and older aspen left untouched by the fire. As with removal of competing conifers, the footprint or the area occupied by aspen in these landscapes will be increased to the area occupied by lateral roots surrounding groves (Keyser et al., 2005).

Prescribed crown fire can be used in mid to late successional aspen/conifer forests where conifer crown bulk density is sufficient to carry a crown fire (Shepperd 2004). This technique requires natural fuel breaks to keep the fire from spreading outside desired treatment areas. Such burns should be planned when soil moisture is high, to avoid excessive damage to the shallow aspen roots. Although it resembles a wildfire (killing all existing aspen as well as conifers), prescribed crown fire will not only rejuvenate aspen and reset vegetation succession, it will also increase understory vegetation diversity, forage production, and water yields, as well as improve habitat for many wildlife species (Bartos and Campbell 1998).

Combined Treatment Techniques—Combining mechanical treatment and prescribed fire is often the best course of action to regenerate aspen in mixed aspen-conifer stands. A combined treatment emulates natural fire regimes by providing maximum hormonal stimulation and optimal growth environments for aspen sprouts as well as eliminating or reducing competing conifers. Combined treatments work best where fuel loadings are not excessive (Shepperd et al. (2006). Burning heavy logging slash in harvested areas can be detrimental to aspen sprouting, especially when conditions are dry, but excessive root damage can be avoided and adequate sprouting can be maintained if soil conditions are wet when burning heavy slash (Shepperd et al. 2006).

Sudden Aspen Decline

The assessment and restoration activities described above may not be effective in cases where aspen stands are affected by Sudden Aspen Decline (SAD). These situations are characterized by a rapid and complete mortality of mature aspen trees, without an accompanying sprouting event (Worrall et al. 2008). Pre-existing sprouts and younger age cohorts normally survive a SAD event, but the lack of subsequent sprouting indicates a root system decline that has been verified through field sampling (Worrall et al. 2008). This apparent mortality of roots in aspen affected by SAD means that many of these stands might permanently disappear from western landscapes. Research is currently underway to see if preemptive regeneration of aspen not yet affected by SAD can avoid root system mortality and keep aspen present where it otherwise might disappear. In the meantime, careful monitoring of aspen is warranted to document the spread of SAD and further refine the conditions associated with its occurrence.

Summary

Aspen, like many disturbance-dependent western forest types has been affected over the past 150 years by the interruption of natural fire cycles and other human-induced stresses. Restoration of aspen in western landscapes requires recognition of factors affecting its health and vigor and its unique vegetative regeneration characteristics. Management activities need to incorporate steps to assess the occurrence and condition of aspen and respond with appropriate action for each individual circumstance.

Literature Cited

Baker, D.L., Andelt, W.F., Burnham, K., and Shepperd, W.D. 1999. Effectiveness of hot sauce® and deer away® repellents for deterring elk browsing of aspen sprouts. *Journal-of-Wildlife-Management.* 63 : (4):1327-1336.

Bartos, D.L. and Campbell, R.B.Jr. 1998. Decline of quaking aspen in the Interior West--examples from Utah. *Rangelands.* 20: (1):17-24.

Burton, D. 2004. *An implementation monitoring protocol for aspen.* Transactions of the Western Section of the Wildlife Society. 40: 61-67.

Fechner, G.H. and Barrows, J.S. 1976. *Aspen stands as wildfire fuel breaks*. U.S Department of Agriculture. Forest Service, Rocky Mountain Forest and Range Experiment Station. (Eisenhower Consortium Bulletin 4):29 pp.

Jones, B.E., Rickman, T.H., Vazquez, A., Sado, Y., and Tate, K.W. 2005. Removal of encroaching conifers to regenerate degraded asepn stands in the Sierra Nevada. *Restoration Ecology.* 13: (2):373-379.

Jones, J.R., Shepperd, W.D. and DeByle, N.V. 1985. *Intermediate treatments*. In DeByle, N.V. and Winokur, R.P., editors. *Aspen: ecology and management in the western United States*. General Technical Report RM 119,. Fort Collins, CO, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. p 209-216.

Kay, C.E. 1993. Aspen seedlings in recently burned areas of Grand Teton and Yellowstone National Parks. *Northwest Science*. 67: (2):94-104.

Kees, G. 2004. *Fencing out wildlife: plastic mesh fences and electric fences monitored by satellite telemetry.* Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center, Tech. Rep. 0424-2838-MTDC. 18 p.

Keyser, T.L., Smith, F.W. and Shepperd, W.D. 2005. Trembling aspen response to a mixed-severity wildfire in the Black Hills, South Dakota, USA. *Canadian Journal of Forest Research*. 35: 2679-2684.

Kota, A. 2005. *Fences and on-site forest materials as unglate barriers to promote aspen persistence in the Black Hills* [M.S. Thesis]. Logan, Utah: College of Natural Resources, Utah State University74 p.

Mueggler, W.F. 1988. *Aspen community types of the Intermountain Region*. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, GTR-INT-250. 135 p.ADP-HC.

Quinn, R.D., Wu, L. 2001. *Quaking aspen reproduce from seed after wildfire in the mountains of southeastern Arizona.* In: Shepperd, Wayne D, Binkley, Dan, Bartos, Dale L., Stohlgren, Thomas J., and Eskew, Lane G., compilers. 2001. *Sustaining aspen in western landscapes: Symposium Proceedings*, *13-15 June 2000, Grand Junction, CO*. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p369-376.

Rolf, J.M. 2001. *Aspen fencing in Northern Arizona: a 15-year perspective*. In: Shepperd, W.D., Binkley, D., Bartos, D.L., Stohlgren, T.J., and Eskew, L.G., (compilers). *Sustaining aspen in western landscapes: symposium proceedings, 13-15 June 2000, Grand Junction, CO*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p193-196.

Romme, W.H., Turner, M.G., Gardner, R.H., Hargrove, W.W., Tuskan, G.A., Despain, D.G., and Renkin, R.A. 1997. A Rare Episode of Sexual Reproduction in Aspen (Populus Tremuloides Michx.) Following the 1988 Yellowstone Fires. *Natural-Areas-Journal.* 17: (1):17-25.

Rumble, M.A., Pella, T., Sharps, J.C., Carter, A.V., and Parrish, J.B. 1996. Effects of Logging Slash on Aspen Regeneration in Grazed Clearcuts. *Prairie-Naturalist.* 28: (4):199-210.

Shepperd, W.D. 1993. *Initial growth, development, and clonal dynamics of regenerated aspen in the Rocky Mountains.* Res. Pap. RM 312. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station. 8p.

Shepperd, W.D. 2001. *Manipulations to regenerate aspen ecosystems*. In: Shepperd, W.D., Binkley, D., Bartos, D.L., Stohlgren, T.J. and Eskew, L.G., comps. *Sustaining aspen in western landscapes: symposium proceedings; 2000 June 13-15*; *Grand Junction, CO*. RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 355-365.

Shepperd, W.D. 2004. Techniques to restore aspen forests in the western U.S. *Transactions of the Western Section of the Wildlife Society.* 40: 52-60.

Shepperd, W.D., Mata, S.A. 2005. *Planting Aspen to Rehabilitate Riparian Areas: A Pilot Study*. Res. Note RMRS-RN-26. Ft. Collins, CO, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station 5 p.

Shepperd, W.D., Rogers, P.C., Burton, D. and Bartos, D.L. 2006. *Ecology, biodiversity, management, and restoration of aspen in the Sierra Nevada.* Gen. Tech. Rep. RMRS-GTR-178. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 122p.

Worrall J.J., Egeland L, Eager T, Mask R.A., Johnson E.W., Kemp P.A., Shepperd W.D. 2008. Rapid mortality of Populus tremuloides in southwestern Colorado, USA. *Forest Ecology and Management* 255(3-4): 686-696.