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Aspen Ecosystems: Objectives for Sustaining Biodiversity

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Abstract—*Recognizing the historical abundance of major vegetation cover types is the foundation for estimating the magnitude and significance of conversion from one cover type to another and the proportion of existing cover types that are in properly functioning condition. Techniques to determine desired conditions are discussed. Existing situations for the need to treat ecosystems where aspen (*Populus tremuloides *Michx.) occur are prioritized: highest—mixed-conifer with aspen but where conifers comprise greater than 50% of the canopy; high—aspen/sagebrush transition; and moderate—aspen dominated landscapes. Though aspen stands are evaluated, aspen landscapes are discussed in the context of aggregations of many stands. Within aspen dominated landscapes, five risk factors help determine the need for action: (1) conifer understory and overstory cover is greater than 25%; (2) aspen regeneration (5–15 feet tall) is less than 500 stems/acre; (3) aspen canopy cover is less than 40%; (4) dominant aspen trees are greater than 100 years old; and (5) sagebrush cover is greater than 10%. Management recommendations for treatments, as well as examples of successes and failures of efforts to restore aspen ecosystems, are summarized. Actions to restore aspen ecosystems must not be taken before excessive browsing by livestock and wildlife is addressed.*

Introduction

Quaking aspen is the most widely distributed tree species in North America and as such has tremendous ecological amplitude. On a local scale, this ecological amplitude is manifested by the species' ability to occupy sites over great elevational ranges, differing aspects, and contrasting soils from deep mollisols to steep talus and scree slopes.

Aspen Clones

The clonal habit of quaking aspen adds to its uniqueness among tree species. It is possible for a clone with as many as 50,000 stems, all genetically identical, to occupy more than 200 acres and trace their common heritage to the germination of a single aspen seedling perhaps millennia ago (Barnes 1975; Kemperman and Barnes 1976). Such a clone has weathered the test of time on that site. Even the most decadent clones should be recognized as superior genotypes that have survived the process of natural selection and are most likely some of the best suited genetic material for that site.

Aspen clones exhibit high genetic diversity. Clones on similar sites may respond differently to treatments or environmental stresses. Such differences may be manifest in the number of suckers produced, browsing impacts, susceptibility to certain diseases, frost damage, and so on. Always keep the clonal concept in mind when comparing the responses of different aspen stands.

The preceding information gives insights about aspen, the species itself. However, for the remainder of this discussion, we shift the focus from a single tree species to the unique ecosystems that occur and are sustained when aspen

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dominates stands and provides a mosaic of compositionally and structurally diverse patches on the landscape. Aspen dominated landscapes are an aggregation of many aspen dominated stands and perhaps other stands where aspen remains a component of the canopy.

A Keystone Species

Wilson (1992) explained the concept of keystone species with the following passage:

> In communities there are little players and big players, and the biggest players of all are the keystone species. As the name implies, the removal of a keystone species causes a substantial part of the community to change drastically.

He defined a keystone species as:

> A species that affects the survival and abundance of many other species in the community in which it lives. Its removal or addition results in a relatively significant shift in the composition of the community and sometimes even in the physical structure of the environment.

Aspen is a keystone species. With the exception of riparian areas, aspen communities are considered the most biologically diverse ecosystems in the Intermountain West (Kay 1997). However, as aspen dominated landscapes convert to other cover types, tremendous biodiversity is lost (Bartos and Amacher 1998; Bartos and Campbell 1998a,b). These losses include not only vascular plants and vertebrate animals but also nonvascular and invertebrate organisms. Thus, measures taken to sustain aspen ecosystems will also meet coarse-filter objectives for sustaining biodiversity.

Properly Functioning Condition

In 1996, the Intermountain Region of the USDA Forest Service began a process that expanded the concept of proper functioning condition introduced by the Bureau of Land Management (Barrett et. al. 1993) and originally applied only to riparian communities. This new concept of properly functioning condition applied to the major upland vegetation cover types and provided an ecological basis for a rapid assessment of general conditions of sustainability on large landscapes. Properly functioning condition is defined with this statement (USDA Forest Service 1997):

> Ecosystems at any temporal or spatial scale are in properly functioning condition when they are dynamic and resilient to perturbations to structure, composition, and processes of their biological or physical components.

That definition is often too technical to use with general audiences (e.g., school classes or public meetings). This alternate definition attempts to convey the same meaning:

> Properly functioning condition exists when soil and water are conserved, and plants and animals can grow and reproduce and respond favorably to periodic disturbance.

Properly functioning condition is not a single state in time or space. Indeed, properly functioning condition includes a range of conditions and situations that allow for the full variation of composition (numbers and kinds of species) and structure (size and age classes) within the processes of functioning ecosystems for that specific cover type.

Properly functioning condition is intended to be a rapid assessment, a triage, to prioritize general conditions on large landscapes. Assessments were made at multiple scales. Some assessments were made for the entire Intermountain Region. Then a more detailed assessment was made for the Utah High Plateaus and Mountains section in south-central Utah. The concept of properly functioning condition used in this paper ties to all of these assessments. The ideas presented in this paper are applicable, at a minimum, throughout the Intermountain West.

Historical Conditions

Baker (1925) wrote about aspen in the central Rocky Mountains and included a fire history case study from Ephraim Canyon on the Wasatch Plateau in central Utah:

> …These results indicate that small, light fires occurred at intervals of 7 to 10 years in the same general region previous to the settlement of the country. After the logger and stockman invaded the mountains, there was a period of frequent and larger fires, after which fires became fewer and fewer, and now virtually none occur.
> …Conifers are, of course, more resistant to fire when past the sapling stage, but once destroyed they seed in slowly. A 50-year fire rotation would probably keep conifers entirely out of all the aspen type, except on north slopes or in moist localities favorable to the rapid development of the coniferous trees, although aspen would flourish under such conditions. But under present conditions, fire is not a factor to be reckoned with in forest management in the aspen zone.

Baker's description from 75 years ago is a valuable assessment from a trained forest examiner.

We assume that if aspen are present, even a single aspen, then the area has had an aspen cover type at some time during the past 200 to 400 years. The areas where aspen occur typically had fire return intervals of 20 to 60 years. Aspen are not considered capable of establishing true seedlings under a conifer canopy. True aspen seedlings in the Great Basin and central and southern Rocky Mountains would be extremely rare to nonexistent, but aspen do regenerate profusely following a fire. In these situations, the aspen cover type might be considered a fire induced disclimax rather than an early seral stage. Some feel that it is "normal succession" for aspen to be replaced by a conifer cover type. Based on Baker's (1925) observations and these assumptions, we affirm that it is not "normal" for conifers to completely replace the aspen cover type. However, historical aspen cover types are replaced by conifers or sagebrush with the absence of frequent fires and the presence of heavy browsing by livestock and wildlife.

Repeat photos or historical photos (Rogers et. al. 1984; Kay, in press), fire histories (Chappell et. al. 1997), and landscape assessments (Jackson et. al. 1998) combine to provide an indication of the abundance, historically, of the major cover types on the Fishlake National Forest.

Soils inventories can also be used to provide a better understanding of the historical cover types for certain landscapes. The Fishlake National Forest is fortunate to have the soils mapped and GIS layers created at a scale of 1:24,000 largely through the efforts of soil scientist Michael D. Smith. We displayed this information for the Monroe Mountain subsection and reported that the historical (during the past 200 to 400 years) abundance of the aspen cover type was nearly 71,000 acres (Bartos and Campbell 1998a). Of that amount, currently about 17,000 acres remain in the aspen cover type. Almost 42,000 acres is dominated by mixed-conifers [largely subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) with some Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco)] scattered throughout. Also, mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*

(Rydb.) Beetle) replaced the aspen cover type on nearly 12,000 acres. Fire history data, soils survey data, presence of old aspen logs in a sea of sagebrush, and abundance of heavily browsed aspen suckers at the sagebrush/aspen ecotones all indicate that fewer fires and heavier ungulate pressure contributed to this cover type conversion. Aspen decline occurs when landscapes with aspen are outside of properly functioning condition.

The desired condition should not be identical to the historical condition. Much has changed on these landscapes. Changes include new socioeconomic factors that preclude the landscapes from returning to presettlement conditions.

Social Assessments

We talk about properly functioning condition and desired conditions. Some might say, "Properly functioning condition, how pompous!" Others may question, "Properly functioning to whom? Desired to whom?" The answers to these questions are really social assessments. The techniques necessary to determine desired conditions are those that promote and encourage healthy interpersonal relations. Use of the following 4 C's in the planning and management phases helps determine the desired condition for a landscape (Mrowka and Campbell 1997):

- Commitment: devote the time and resources to allow the process to occur and mature.
- Communication: talk and interact willingly and openly with each other.
- Collaborative sharing: promote intense and enthusiastic sharing of information.
- Cooperation: work together; walk the talk; make it happen!

Without consistent application of these key concepts, support for efforts to move these landscapes toward the desired condition within the range of properly functioning condition will not mature. And most landscapes with aspen present will not be sustained into the next century or even decades in some cases.

Characteristics of Aspen Stands in Properly Functioning Condition

Aspen stands in properly functioning condition will often have the following characteristics: multi-aged stems in the stand, adequate regeneration to perpetuate the stand, age classes mostly less than 100 years old, and good undergrowth beneath the canopy. Both compositional and structural diversity are important.

An argument could be made for any acre of land to be in properly functioning condition as long as that acre does not have compositional and structural characteristics similar to most of the surrounding area. Comparing and contrasting a smaller area (e.g., the stand) in the context of a larger landscape is critical to recognizing the diversity of a landscape in properly functioning condition. Landscapes (aggregations of stands) that are compositionally and structurally homogeneous are not in properly functioning condition.

Risk Factors for Stands With Aspen

We prioritized situations where actions are needed to sustain landscapes with aspen. The highest priority is the mixed-conifer/aspen cover type (particularly where subalpine fir dominates). High priority exists for the aspen/sagebrush transition. Also, action is needed on aspen dominated landscapes where the risk factors are present (Bartos and Campbell 1998a). The five risk factors for aspen dominated stands are:

- conifer cover (understory and overstory) greater than 25%;
- aspen canopy cover less than 40%;
- dominant aspen trees greater than 100 years old;
- aspen regeneration less than 500 stems per acre (5 to 15 feet tall); and
- sagebrush cover greater than 10%.

Prioritized Key to Risk Factors for Landscapes With Aspen

The risk factors described above are considered in the prioritized key to risk factors associated with stands where aspen is present in the Intermountain West (table 1). We feel that the ecological underpinnings of this key have application to areas beyond the Intermountain West. However, we recognize that within the extensive range of quaking aspen distribution, there might be situations where this key is not applicable.

Three different categories of cover are referred to in this key. Canopy cover is the percent of the ground surface that is covered from directly overhead by the crowns of dominant and codominant trees. Overstory cover would be that cover that is provided by trees, including the subcanopy, that are greater than 5 feet tall. Understory cover is the percent of ground covered by individual plants that are less than 5 feet tall.

In the key, couplet 1 refers to relative cover; couplets 2 through 5 use absolute cover. Therefore, elements 1b and 2a are not inconsistent. In couplet 1, for example, even though total conifer canopy cover might be 60%, if total aspen canopy cover is 70%, then 1b is the appropriate choice. Also, for element 2a to be selected, the actual aspen canopy cover could be 35% while the conifer canopy cover might be 25%, but sagebrush would exceed 15% cover.

Clearly, situations that have the greatest risk and the highest priority are those where canopy cover from conifer species combined exceed the canopy coverage from aspen. These are mixed-conifer rather than aspen cover types.

Table 1—Key to the risk factors used to prioritize areas with aspen for restoration and conservation actions in the Intermountain West. Assumption: Aspen are present with a density of at least 20 mature trees per acre. Note: Couplet 1 refers to relative cover; couplets 2 to 5 use absolute cover.

1. a. Conifer species comprise at least half of the canopy cover.	Highest priority
b. Aspen comprises more than half of the total canopy cover.	2
2. a. Aspen canopy cover is less than 40%; *and* sagebrush, usually a dominant understory species, exceeds 15% cover.	High priority
b. Not as above.	3
3. a. Conifer cover (including overstory and understory) exceeds 25%.	Moderate to high priority
b. Conifer cover is less than 25%.	4
4. a. Aspen regeneration (5 to 15 feet tall) is less than 500 stems per acre.	Moderate priority
b. Aspen regeneration exceeds 500 stems per acre.	5
5. a. Any two of the following three risk factors are represented: 1—Aspen canopy cover is less than 40%. 2—Dominant aspen trees are greater than 100 years old. 3—Sagebrush cover exceeds 10%.	Low to moderate priority
b. Two of the three risk factors in 5a are not represented.	6
6. a. One of the three risk factors in 5a is represented.	Low priority
b. None of the risk factors above are represented.	Candidate for properly functioning condition

However, with proper treatments the aspen cover type can usually be restored and sustained. The literature is sparse with reference to stocking or the minimum number of mature aspen that are necessary to expect adequate regeneration of the aspen stand. Peterson and Peterson (1992) provided some guidelines applicable to Ontario and suggested stands need at least 16 parent aspen stems per acre to produce the minimal acceptable stocking and about 50 parent aspen stems per acre to fully stock a stand. Thus, for the key, we assume that at least 20 mature trees per acre are present. There might not be sufficient aspen roots to restock a stand if fewer than 20 trees per acre are on site. Also, areas with aspen canopies less than 40% and sagebrush greater than 15% have a high risk and high priority for aspen restoration treatments. As the risk factor key indicates, stands dominated by aspen have a lower risk and lower priority for treatments to sustain the aspen ecosystems. However, if some situations are not addressed, even these stands might not be sustained into the 22nd Century.

Rules of Thumb to Identify Aspen Stands at Risk

1. If the profile of the aspen stand is rounded or sloping to the ground with foliage extending to the ground, the stand is probably not seriously at risk. If the white boles of mature trees can be seen from a distance, then the stand is most likely at risk. However, if the edge of a stand also marked the boundary of a clearcut, then the stand may not be at risk and young aspen will grow up in the clearcut to eventually mask the white boles at the edge of the stand.

2. Often we can observe aspen stands on distant ridges from the valley or other areas below the stand. Conditions are not right in the stand if sky can be seen between the canopy of the stand and the ground or understory in the stand.

3. Where aspen occurs at the sagebrush transition, if careful inspection of individual sagebrush plants adjacent to (within 25 to 100 feet) an aspen stand reveals young aspen suckers that have been hedged or browsed for several years and yet are still trying to grow, then the stand might be considered at risk of loosing the aspen component. Hedging and browsing of the aspen regeneration is likely occurring also within the aspen stand to the point that most if not all of the regeneration is gone. These individual sagebrush plants become tiny exclosures that offer some protection to the aspen suckers. Such an observation confirms that the aspen stand is still capable of regeneration but not in the presence of heavy ungulate use.

Possible Actions or Treatments for Landscapes With Aspen

Several possible actions or treatments are available for managers to use in treating landscapes where aspen ecosystems are declining and not in properly functioning condition. These actions include:

- rest from use by domestic animals;
- use protection fencing to keep out wildlife and/or domestic animals;
- harvest (remove or cut and leave on site);
- burn (prescribed fires, wildland fire use, and/or wildfires);
- tip over mature trees (use bulldozers to chain or push over trees); and
- sever roots (use single-toothed ripper or similar equipment).

Detailed discussion of these treatments is beyond the scope of this paper. (For further information, see Bartos and Mueggler 1981, Bartos and Mueggler 1982, Bartos et. al. 1991; Kay and Bartos 2000; Mueggler and Bartos 1977; Shepperd 1993; Shepperd 1996.) However, characteristics of the clones, abundance of aspen in acres occupied, potential for utilization by ungulates, fuel loading, available funding, and site conditions are all factors to consider when planning the types of actions used to implement a treatment.

Relief From Excessive Browsing Is Essential

Unwanted utilization of aspen suckers by livestock and wildlife in treated areas is a major reason why many actions fail to rejuvenate and sustain aspen stands. The following statement underscores this situation:

> Heavy browsing of the suckers can deplete aspen root reserves, jeopardize successful regeneration, and threaten the very survival of the aspen stand. Coordinated and difficult decisions are needed before suckering will be successful. *Actions to induce suckering must not be initiated before relief from excessive browsing is obtained* [italics added] (USDA Forest Service 1994).

Examples of both successful aspen regeneration and failures following treatments (e.g., burns and harvests) in areas with aspen present are plentiful. Exclosures and fenceline contrasts provide ample evidence that success (or failure) is often keyed to the absence (or presence) of domestic and/or wild ungulates.

Recommendations

Recommendations for managing landscapes with aspen will require managers to be creative and use the 4 C's (commitment, communication, collaborative sharing, and cooperation) as they endeavor to restore and sustain aspen ecosystem in properly functioning condition. We challenge managers to be bold.

First, take action now! Do not let another decade or two slip by without substantial treatments on the landscape. Gullion (1985) gave a passionate plea for action:

> Some sites that have lost aspen might still be stocked, had a regeneration program started 10 or 20 years ago. Due to their decadence now, it will be difficult to obtain quality regeneration of many stands today, and each year more stands will move into that category. In 30 years, it will be too late to rejuvenate many of the mature stands that are such an important part of Colorado's wildlife habitat and visual resources today.

Fifteen years have now passed since Gullion's call for action. Have sufficient acres been treated in the past 15 years to restore and sustain the diversity of composition and structure?

Second, make actions large. Where landscapes with aspen present are sufficiently large, treat 500 to 1,000+ acres at a time. These acres need not be contiguous but could be several smaller treatments in the same expanded project area. This will help to restore the structural mosaic to the landscape. Also, the larger areas treated will help disperse ungulate pressures, domestic and/or wild.

Third, take action often. Persistence over time is important. A program of successive actions will help to restore structural diversity to these landscapes.

References

Baker, Frederick S. 1925. Aspen in the central Rocky Mountain region. USDA Bull. 1291. 47 p.

Barnes, Burton V. 1975. Phenotypic variation of trembling aspen in western North America. Forest Science. 21(3): 319–328.

Barrett, Hugh; Cagney, Jim; Clark, Ron; Fogg, Jim; Gebhart, Karl; Hansen, Paul L.; Mitchell, Brenda; Prichard, Don; Tippy, Dan. 1993. Riparian area management: process for assessing proper functioning condition. TR 1737-9. U.S. Department of the Interior, Bureau of Land Management. 52 p.

Bartos, Dale L.; Amacher, Michael C. 1998. Soil properties associated with aspen to conifer succession. Rangelands. 20(1): 25–28.

Bartos, Dale L.; Campbell, Robert B., Jr. 1998a. Decline of quaking aspen in the Interior West—examples from Utah. Rangelands. 20(1): 17–24.

Bartos, Dale L.; Campbell, Robert B., Jr. 1998b. Water depletion and other ecosystem values forfeited when conifer forests displace aspen communities. In: Potts, Donald F., ed. Proceedings of AWRA specialty conference, rangeland management and water resources. TPS-98-1. Herndon, VA: American Water Resources Association: 427–434.

Bartos, Dale L.; Mueggler, Walter F. 1981. Early succession in aspen communities following fire in western Wyoming. Journal of Range Management. 34(4): 315–318.

Bartos, Dale L.; Mueggler, Walter F. 1982. Early succession in aspen communities following clearcutting of aspen communities in northern Utah. Journal of Range Management. 35(6): 764–768.

Bartos, Dale L.; Mueggler, Walter F.; Campbell, Robert B., Jr. 1991. Regeneration of aspen by suckering on burned sites in western Wyoming. Res. Pap. INT-448. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 10 p.

Chappell, Linda; Greenhalgh, Kevin; Campbell, Robert. 1997. A fire history study conducted on the Monroe Mountain demonstration area: Richfield District, Fishlake National Forest. Richfield, UT: U.S. Department of Agriculture, Forest Service, Fishlake National Forest. 24 p.

Gullion, Gordon W. 1986. Impact of aspen management on Rocky Mountain wildlife. In: Comer, Robert D., ed. 1986. Issues and technology in the management of impacted western wildlife: proceedings of a national symposium; 1985 February 4–6; Glenwood Springs, CO. Boulder, CO: Thorne Ecological Institute: 276–281.

Jackson, Linda L.; Campbell, Robert B.; Chappell, Linda M.; Greenhalgh, Kevin; Shiverdecker, Wallace T.;. Weaver, Doug A. 1998. Fishlake National Forest prescribed natural fire plan: fire management situation and fire management action plan. Richfield, UT: U.S. Department of Agriculture, Forest Service, Fishlake NF. 146 p.

Kay, Charles E. 1997. Is aspen doomed? Journal of Forestry. 95(5): 4–11.

Kay, Charles E. [In press]. The use of repeat photos to evaluate long-term vegetation change and land management in south-central Utah. 179 plates.

Kay, Charles E.; Bartos, Dale L. 2000. Ungulate herbivory on Utah aspen: assessment of long-term exclosures. Journal of Range Management. 53(2): 145–153.

Kemperman, Jerry A.; Barnes, Burton V. 1976. Clone size in American aspen. Canadian Journal of Botany. 54: 2603-2607.

Mueggler, W. F; Bartos, D. L. 1977. Grindstone Flat and Big Flat exclosures—a 41-year record of changes in clearcut aspen communities. Res. Pap. INT-195. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 16 p.

Mrowka, Rob; Campbell, Robert B., Jr. 1997. Cooperative management of the Monroe Mountain ecosystem. In: Diverse forests, abundant opportunities, and evolving realities: proceedings 1996 Society of American Foresters convention; 1996 November 9–13; Albuquerque, NM: 166–171.

Peterson, E. B.; Peterson, N. M. 1992. Ecology, management, and use of aspen and balsam poplar in the prairie provinces. Canada. Special Rep. 1. Victoria, British Columbia: Forestry Canada, Northwest Region, Western Ecological Services.

Rogers, G. F.; Malde, H. E.; Turner, R. M. 1984. Bibliography of repeat photography for evaluating landscape change. Salt Lake City, UT: University of Utah Press. 179 p.

Shepperd, Wayne D. 1993. The effects of harvesting activities on soil compaction, root damage, and suckering in Colorado aspen. Western Journal of Applied Forestry. 8(2): 62–66.

Shepperd, Wayne D. 1996. Response of aspen root suckers to regeneration methods and post-harvest protection. Res. Pap. RM-RP-324. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

USDA Forest Service. 1994. Sustaining our aspen heritage into the twenty-first century. Albuquerque, NM: U.S. Department of Agriculture, Forest Service, Southwestern Region. 7 p.

USDA Forest Service. 1997. Properly functioning condition: rapid assessment process (including the Properly Functioning Condition Assessment for the Utah High Plateaus and Mountain Section); September 8, 1997. Ogden, UT: Intermountain Region. 71 p.

Wilson, Edward O. 1992. The diversity of life. New York: W. W. Norton and Company. 424 p.