

Utah State University

DigitalCommons@USU

---

Aspen Bibliography

Aspen Research

---

2003

## Aspen Management Guidelines for BLM lands in North-Central Nevada

Charles E. Kay

Follow this and additional works at: [https://digitalcommons.usu.edu/aspen\\_bib](https://digitalcommons.usu.edu/aspen_bib)



Part of the [Forest Sciences Commons](#)

---

### Recommended Citation

Kay, Charles E. 2003. Aspen management guidelines for BLM lands in north-central nevada. Providence, UT: Wildlife Management Services.

This Report is brought to you for free and open access by the Aspen Research at DigitalCommons@USU. It has been accepted for inclusion in Aspen Bibliography by an authorized administrator of DigitalCommons@USU. For more information, please contact [digitalcommons@usu.edu](mailto:digitalcommons@usu.edu).



**ASPEN MANAGEMENT GUIDELINES**

**FOR**

**BLM LANDS IN NORTH-CENTRAL NEVADA**

Final

report

to

Battle Mountain Field Office  
Bureau of Land Management  
50 Batian Road  
Battle Mountain, NV 89820

by

Charles E. Kay, Ph.D. Wildlife Ecology  
Wildlife Management Services  
480 East 125 North  
Providence, UT 84332  
(435) 753-0715

May 2003

## ACKNOWLEDGEMENTS

This research was funded by the Bureau of Land Management (BLM) under contracts FGP 000039, FBP 020036, and FGP 020036, and I thank the agency for its support. BLM specialists Joe Ratliff, Skip Ritter, Ken Wilkinson, Carol Evans, Mike Stamm, and Duane Crimmins were extremely helpful in selecting study sites and providing documents germane to this study. This report is part of a continuing 5 year aspen study (2000-2004) between the Battle Mountain and Elko BLM Districts funded through the 5900 Forest Health and Restoration Program. Joe Ratliff, Project Coordinator with the Battle Mountain Field Office, expresses his appreciation to Rick Tholen, 5900 Project Lead, for his valued support and assistance in making this project possible.

---

## TABLE OF CONTENTS

|                                                |     |
|------------------------------------------------|-----|
| ACKNOWLEDGEMENTS.....                          | i   |
| TABLE OF CONTENTS.....                         | ii  |
| LIST OF TABLES.....                            | iii |
| LIST OF FIGURES.....                           | iv  |
| ABSTRACT.....                                  | v   |
| INTRODUCTION.....                              | 1   |
| METHODS.....                                   | 5   |
| RESULTS AND DISCUSSION.....                    | 8   |
| Exclosures.....                                | 11  |
| De Facto Exclosures.....                       | 15  |
| Ungulate Use Data.....                         | 18  |
| Temporary Livestock Reductions.....            | 22  |
| Fire.....                                      | 25  |
| Beaver.....                                    | 28  |
| MANAGEMENT RECOMMENDATIONS AND GUIDELINES..... | 32  |
| LITERATURE CITED.....                          | 45  |

**LIST OF TABLES**

| <b>Table</b>                                                             | <b>Page</b> |
|--------------------------------------------------------------------------|-------------|
| 1. Aspen study sites on BLM lands in north-central Nevada.....           | 9           |
| 2. Aspen containing exclosures on BLM lands in north-central Nevada..... | 12          |

## LIST OF FIGURES

| Figure                                                                                                            | Page |
|-------------------------------------------------------------------------------------------------------------------|------|
| 1. A typical aspen stand in decline on BLM lands, West Fork of Beaver Creek, Elko District .....                  | 10   |
| 2. Aspen regeneration inside the Billie Creek exclosure, Desatoya Mountains, Battle Mountain District .....       | 13   |
| 3. Aspen regeneration inside a small exclosure built by BLM in Oregon Canyon on the Elko District .....           | 14   |
| 4. A typical aspen understory outside the Bates Mountain exclosure on the Battle Mountain District .....          | 16   |
| 5. Typical understory vegetation inside the Bates Mountain exclosure on the Battle Mountain District .....        | 17   |
| 6. A de facto aspen exclosure on BLM lands in the Adobe Mountains, Elko District .....                            | 19   |
| 7. Another type of de facto aspen exclosure on BLM lands in north-central Nevada .....                            | 20   |
| 8. A typical aspen sucker on BLM lands in north-central Nevada .....                                              | 21   |
| 9. A typical aspen stand on the east side of Stag Mountain on the Elko District .....                             | 23   |
| 10. A typical aspen stand on the west side of Stag Mountain on the Elko District .....                            | 24   |
| 11. The effect of cattle grazing on aspen regeneration following fire, Stag Mountain, Elko District .....         | 26   |
| 12. A typical burned, but ungrazed, aspen stand on Stag Mountain, Elko District .....                             | 27   |
| 13. The effect of beaver and repeated livestock browsing on aspen in north-central Nevada .....                   | 30   |
| 14. The effect of beaver and cattle on aspen along Connors Creek, Elko District .....                             | 31   |
| 15. An example of an aspen stand in good ecological condition, Desatoya Mountains, Battle Mountain District ..... | 35   |
| 16. An example of a see-through aspen stand in the Beaver Creek drainage on the Elko District .....               | 36   |
| 17. Aspen data sheet used to record aspen stand parameters on BLM lands in north-central Nevada .....             | 38   |

## ABSTRACT

Aspen is of special concern in the West because the species does not commonly grow from seed due to its demanding seed-bed requirements. It is thought that environmental conditions have not been conducive to seedling growth and clonal establishment since shortly after the glaciers retreated 10,000 or more years ago. Hence, aspen clones found in north-central Nevada today have likely maintained their presence on those sites for thousands of years via vegetative regeneration; i.e. root sprouting. In addition, aspen communities support an array of other species and have the highest biodiversity of any upland forest type in the West. This is especially true in north-central Nevada where many aspen stands are associated with riparian habitats. Aspen, though, has been declining in Nevada and throughout the Intermountain West since shortly after European settlement. The reasons for this have been attributed to climatic change, fire suppression, normal plant succession, wild ungulate browsing, and/or grazing by domestic livestock.

To test these hypotheses and to determine the status of aspen on BLM administered lands in north-central Nevada, I measured 348 representative aspen stands at 14 different locations. I also measured or otherwise evaluated 30 aspen-containing exclosures in those same areas. The exclosures were originally built to study the effect of livestock use, but because the general climate is the same inside and outside the fenced plots, the exclosures can also be used to evaluate the climatic change hypothesis. The same is true of de facto exclosures created by fallen aspen trees or other physical barriers.

Many aspen stands in north-central Nevada have not produced new stems greater than 6 feet tall in nearly 100 years and many stands are in very poor ecological condition. **The status and trend of aspen communities in north-central Nevada, however, is not related to climatic variation, fire suppression, forest succession, or browsing by mule deer. Instead, the condition of individual aspen communities is related to past and present levels of livestock grazing.** That is, aspen is declining throughout most of north-central Nevada due to repeated browsing of aspen suckers by cattle and/or domestic sheep - - repeated browsing eliminates sucker height growth, which prevents their maturation into aspen saplings and trees. Without stem replacement, aspen clones are consigned to extinction.

This cause and effect relationship is most clearly demonstrated inside and outside exclosures. In all cases where it was protected, aspen successfully regenerated without fire or other disturbance, while on adjacent, outside plots, aspen continued to decline. Aspen in north-central Nevada also experienced major regeneration events on allotments where livestock use was reduced. Fire can be used to stimulate aspen regeneration, but burned aspen stands must be rested for several years until the majority of new stems are beyond the reach of livestock; i.e., 7 feet tall. Beaver-felled aspen also need to be protected or repeated livestock use will eliminate those clones, as has already happened on several allotments.

**Thus, to reverse the decline of aspen in north-central Nevada it will be necessary to more closely manage livestock.** Depending on individual sites and the present condition of aspen, it may be necessary to fence more critical stands and/or restrict livestock to only early-season grazing. If aspen does not respond to those

measures, it may be necessary to reduce AUM numbers or close some allotments where problems are acute. It is also recommended that BLM establish permanent monitoring plots in representative aspen communities throughout the Battle Mountain and Elko Districts to evaluate management actions related to that species.

## INTRODUCTION

Aspen (Populus tremuloides) is an excellent indicator of ecosystem health and ecological integrity in the western United States because the species does not commonly grow from seed due to its demanding seed-bed requirements (Perala 1990; West et al. 1994:10; White et al. 1998a, 1998b). In fact, there are no known instances of aspen clones having established from seed anywhere in the Intermountain West during the period of recorded history (Kay 1993). It is thought that environmental conditions have not been conducive to seedling growth and clonal establishment since shortly after the glaciers retreated 10,000 or more years ago (McDonough 1979, 1985; Perala 1990; Jelinski and Cheliak 1992; Mitton and Grant 1996). **This means that aspen clones found in north-central Nevada today have likely maintained their presence on those sites for thousands of years via vegetative regeneration. Thus, aspen may be among the oldest living organisms on Earth and should be managed as old-growth, ancient forests, not a seral plant community (Grant 1993, Mitton and Grant 1996, Kay 1997a).**

Aspen seedlings are more common in the northern Canadian Rockies (Peterson and Peterson 1992, 1995) and there may be "windows of opportunity" that allow seedling establishment at infrequent, 200 to 400 year or longer, intervals (Jelinski and Cheliak 1992:728), but successful sexual reproduction of aspen is still exceedingly rare (Mitton and Grant 1996). Aspen invariably occurs as clones in which all the individual trees (ramets) are genetically identical, having grown from a common root system by vegetative shoots. If aspen is lost, there are no known practical means of reestablishing those clones (Kay 1997a, Shepperd and Battaglia 2002:92).

As a relatively short-lived tree (<150 years), long-lived aspen clones are often dependent on periodic disturbance such as fire to stimulate vegetative regeneration via root suckering, and to reduce conifer competition (Bartos and Mueggler 1979, 1981;

Bartos et al. 1991, 1994; Shepperd 1993; Shepperd and Smith 1993). In the absence of fire, many aspen clones in the Intermountain West may be replaced by more shade-tolerant species, although climax aspen is common (Mueggler 1988). Aspen, however, will burn only when it is leafless and when the understory plants are dry enough to carry a fire, conditions that occur only early in the spring before understory regrowth, and late in the autumn after leaf-fall and the understory plants have cured (Fechner and Barrows 1976, Brown and Simmerman 1986, DeByle et al. 1987). During both those periods, though, there are few lightning strikes and virtually no lightning-started fires in the West (Kay 1997a, 2000). This would suggest that in pre-Columbian times, native burning may have been more important than lightning-started fires in maintaining aspen and other plant communities (Kay 1997a, 1997b, 1997c, 2000). In central Nevada, though, most aspen stands are relatively small and recent wildfires burning under extreme conditions have completely top-killed some clones; i.e. wind-driven wildfires are able to burn through drought-stricken aspen if the stands are not too large or if the clones are highly degraded.

In addition, aspen communities support an array of other species and have extremely high biological diversity (DeByle and Winokur 1985, Peterson and Peterson 1992, Stelfox 1995). **In fact, aspen has the highest biodiversity of any upland forest type in the West (Finch and Ruggiero 1993).** Bird communities, for instance, vary with the size, age, and location of aspen clones, as well as with grazing intensity and history (Young 1973, 1977; Balda 1975; Flack 1976, Page et al. 1978; Winternitz 1980; Casey and Hein 1983; Oakleaf et al. 1983; Taylor 1986; Putman et al. 1989; Daily et al. 1993; Ehrlich and Daily 1993; Johns 1993; Westworth and Telfer 1993; Stelfox 1995; Grant and Berkey 1999). So if aspen is lost, many birds and small mammals will decline; some precipitously (Ehrlich and Daily 1993). This is especially true on BLM lands in north-central Nevada where many aspen communities are found in riparian settings (Schenbeck and Dahlem 1977; Kennedy et al. 2000; Kay 2001a, 2002, 2003).

Moreover, aspen provides highly palatable forage for elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and livestock throughout the West (Wallmo and Regelin 1981, Nelson and Legee 1982, Endersby 1999). Aspen, however, is sensitive to repeated browsing and range-use levels. High-density elk populations commonly strip bark from mature aspen and severely browse aspen suckers that can prevent stand regeneration and which may eventually lead to the loss of aspen clones (Krebill 1972; Olmsted 1977, 1979, 1997; Weinstein 1979; Kay 1985, 1990, 2001b, 2001c; Shepperd and Fairweather 1994; Baker et al. 1997; White et al. 1998a, 1998b, 2003; Ripple and Larson 2000; White 2001). Large numbers of mule deer can also prevent aspen regeneration (Olmstead 1979, Kay and Bartos 2000), and if not properly managed, livestock can have similar negative impacts on aspen communities (Baker 1918, 1925; Sampson 1919; Coles 1965; Weatherill and Keith 1969).

Recent evidence indicates that aspen has been declining throughout the Intermountain West since shortly after European settlement (Schier 1975; Schier and Campbell 1980; Kay 1997a, 1997b; Wall et al. 2001). Since 1962, the acreage of aspen dominated forests in Arizona and New Mexico has decreased by nearly 50% (U.S. Forest Service 1993, Cartwright and Burns 1994, Johnson 1994). While in the northern Rockies, aspen has declined by up to 90% since the late 1800s (Kay 1990, 1997a, 1997c; Kay and Wagner 1994, 1996; Kay et al. 1999). On Idaho's Targhee National Forest, inventory data show that 36% of the West Camas Creek drainage was dominated by aspen in 1914, but today, aspen occupies only 4% of the area - - figures that are confirmed by repeat-photographs (Kay 1997a, 1999). In Utah, aspen has also declined from its historical distribution (Bartos and Campbell 1998). On Utah's Dixie National Forest, for instance, there were historically over 590,000 A. of aspen while today there are only approximately 200,000 A. Furthermore, many aspen stands contain old-age or single-age trees and have not successfully regenerated for 80 years or longer (Mueggler 1989a, 1989b). It has

also been observed that aspen has failed to regenerate and is declining on BLM lands in central Nevada (Schenbeck and Dahlem 1977).

At least four hypotheses have been advanced to explain the decline of aspen throughout the Intermountain West (Kay and Bartos 2000, White et al. 2003). (1) Climatic change - - the climate was more favorable for aspen in the past and today's drier climate precludes aspen regeneration (Despain et al. 1986, Romme et al. 1995, Baker et al. 1997). (2) Conifer invasion and fire suppression - - aspen is a seral species that will not successfully regenerate unless the overstory aspen and invading conifers are killed by fire (Houston 1973, 1982; Loope and Gruell 1973; Gruell and Loope 1974; Despain et al. 1986; Wall et al. 2001), and thus, modern fire suppression and forest succession have adversely effected aspen. (3) Livestock grazing is preventing the growth of aspen suckers into trees (Sampson 1919, Baker 1925). And (4) repeated browsing by mule deer and/or elk is preventing aspen sucker height growth and the successful regeneration of aspen stands (Coles 1965; Bartos and Mueggler 1979, 1981).

To test these hypotheses and to determine the status of aspen on BLM lands, I measured the condition and trend of aspen communities throughout north-central Nevada within the Battle Mountain and Elko Districts. I also measured all aspen-containing exclosures within those study areas. The exclosures were originally built to study the effect of livestock use, but because the general climate is the same inside and outside the fenced plots, they can also be used to test the climatic change hypothesis (Laycock 1975). Various mountain ranges were selected for study by the Bureau of Land Management because aspen stands in those areas were thought to be representative of conditions on the Battle Mountain and Elko Districts.

## METHODS

Within each study area, representative aspen stands were selected for detailed measurement. At each aspen community that was sampled during this study, I first placed a 2x30 m (6.6x98 ft.) belt transect perpendicular to the slope in the stand's center. To facilitate data recording, I subdivided each 30 m transect into 3 m (9.8 ft.) segments and then recorded the number of live aspen stems by size classes within each 3 m segment. I used the following size classes: (1) stems less than 2 m (6.6 ft.) tall, (2) stems greater than 2 m tall but less than 5 cm (2 in.) diameter at breast height (DBH), (3) stems between 6 and 10 cm (2-4 in.) DBH, (4) stems between 11 and 20 cm (4-8 in.) DBH, and (5) stems greater than 21 cm (8 in.) DBH. Ages of aspen within each size class were determined by counting annual rings. I obtained the ages of large aspen with the aid of an increment borer while I cross-sectioned smaller stems, usually those less than 5 cm DBH. Larger trees were cored at breast height, while stems <5 cm in diameter were usually cut at ground level. Stems less than 2 m tall were not aged. The location of each measured aspen stand was plotted on 1:24,000 USGS topographic maps. In addition, the locations of all unmeasured aspen stands within each study area were marked on topographic maps, as were all the routes driven or walked.

Within each stand, I also recorded the following information: (1) location - - section, township, and range; (2) elevation as determined from topographic maps; (3) Universal Transverse Mercator (UTM) grid coordinates, again estimated from topographic maps; (4) aspect - north, northeast, east, southeast, south, southwest, west, and northwest; (5) estimated slope in percent; (6) estimated stand size; (7) an estimate of the mean percent of each stem that had been damaged by ungulate bark stripping - - of the animals commonly found in Nevada, bark stripping is only done by elk, not deer or livestock (Krebill 1972); (8) if the stand had newly regenerated stems greater than 2 m tall but less than 5 cm DBH, an estimate of the percent that showed evidence of ungulate highlining - - where

the ungulates browse off all the lower branches as high as the animals can reach; (9) the percent of stems less than 2 m tall on each 2x30 m transect that exhibited ungulate browsing; (10) whether or not water was present in or near the stand; and (11) the number of cattle, domestic sheep, mule deer, and elk pellet groups on each 2x30 m belt transect. At recently burned stands, I also measured the height of 50 randomly chosen aspen suckers and recorded whether those stems had been browsed or not.

Furthermore, at each stand I recorded the number and species of conifers on the 2x30 m belt transect that was used to count aspen stems. Conifers were recorded by the same five size classes that were used for aspen. In addition, I estimated the total percent conifer canopy cover in each stand according to guidelines established by Mueggler (1988). Understory plant species composition was visually estimated in each sampled aspen stand following procedures developed by Mueggler (1988). Shrubs were identified to species, but the same could not be done with grasses or forbs because those plants had generally received such heavy utilization that they could not reliably be identified (Clary and Leininger 2000). Instead, percent canopy cover was estimated for all grass species and all forb species combined. The proportion of bare soil, rock, and litter, including downed aspen, was also recorded. All aspen selected for detailed study were photographed using 35 mm color slide film to document stand and understory conditions (Magill 1989; Hall 2002a, 2002b). Finally, at each aspen-containing exclosure, data were collected on inside, as well as on adjacent, comparable outside plots (Kay and Bartos 2000).

BLM provided information on the grazing history of each aspen study area. Unfortunately, the agency's files are incomplete and seldom contain data on actual livestock use. Instead, BLM generally has information on AUM (Animal Unit Month) allocations, as well as the number of AUM's each permittee paid to activate in any one year, called grazing bills. Grazing bills, however, may not reflect actual use as many ranches simply pay for all the AUM's they are allocated each year to maintain their grazing

permits. At the end of each grazing season, ranchers are required to submit actual use reports, but those too are only estimates. Therefore, based on the information in BLM's files, it is only possible to document general grazing trends on each allotment. BLM, for instance, does have records on legally mandated changes in AUM allocations. That is to say, have the ranchers' basic AUM authorizations been increased or decreased? BLM also has data on any season-of-use changes that have been implemented by the agency. Again, however, actual use data are lacking because there simply are not enough agency personnel to field check each and every action of its grazing permittees.

## RESULTS AND DISCUSSION

**In all, 348 representative aspen stands were measured in 14 different areas (Table 1) and those data presented to BLM in a series of reports (Kay 2001a, 2002, 2003). The original reports also contain a total of 3,388 - - 35 mm color slides of project aspen stands, a few of which are included in this document as Figures. Many aspen stands in north-central Nevada are in poor ecological condition and have not successfully regenerated in nearly 100 years (Figure 1).** During the present study, elk sign was observed only in the Tuscarora Mountains, so elk have not contributed to the decline of aspen on BLM lands in north-central Nevada. In other areas of the West, however, elk have had and are having serious, negative effects on aspen communities (Kay 1985, 1997a, 1997c, 2001b, 2001c; White et al. 1998a, 1998b, 2003; Ripple and Larsen 2000; White 2001). If elk colonize additional areas in north-central Nevada or are transplanted onto BLM lands, it is highly likely that those animals would have a negative impact on aspen (Wall et al. 2001:697). In Nevada's Jarbridge Mountains, for instance, Beck and Peek (2001) reported that summer elk use was concentrated in aspen.

**Forest succession is also not a problem in the aspen stands that were studied, as conifers had not invaded any of the communities that were measured.** Aside from pinyon (Pinus spp.) and juniper (Juniperus spp.), conifers are generally absent from the mountain ranges that were visited in north-central Nevada. There is also no evidence that normal plant succession favors sagebrush over aspen, as claimed by some (Schenbeck and Dahlem 1975). Where it has been protected from grazing,

Table 1. Aspen study sites on BLM lands in north-central Nevada

| Study Site                        | Number of Plots | Reference |
|-----------------------------------|-----------------|-----------|
| Shoshone Mountains                | 10              | Kay 2001a |
| Simspon Park Mountains            | 29              | Kay 2001a |
| Diamond Mountains                 | 25              | Kay 2001a |
| Toiyabe Mountains                 | 13              | Kay 2001a |
| Desatoya Mountains                | 22              | Kay 2001a |
| Robert's Mountains                | 17              | Kay 2001a |
| Pinon Range                       | 49              | Kay 2002  |
| Little Humboldt                   | 24              | Kay 2002  |
| Winters Creek - - Owyhee Drainage | 10              | Kay 2002  |
| Beaver Creek                      | 44              | Kay 2002  |
| Sheep Corral Canyon               | 7               | Kay 2002  |
| Stag Mountain                     | 52              | Kay 2003  |
| Tuscarora Mountains               | 10              | Kay 2003  |
| Adobe Mountains                   | 13              | Kay 2003  |
| Total                             | 348             |           |

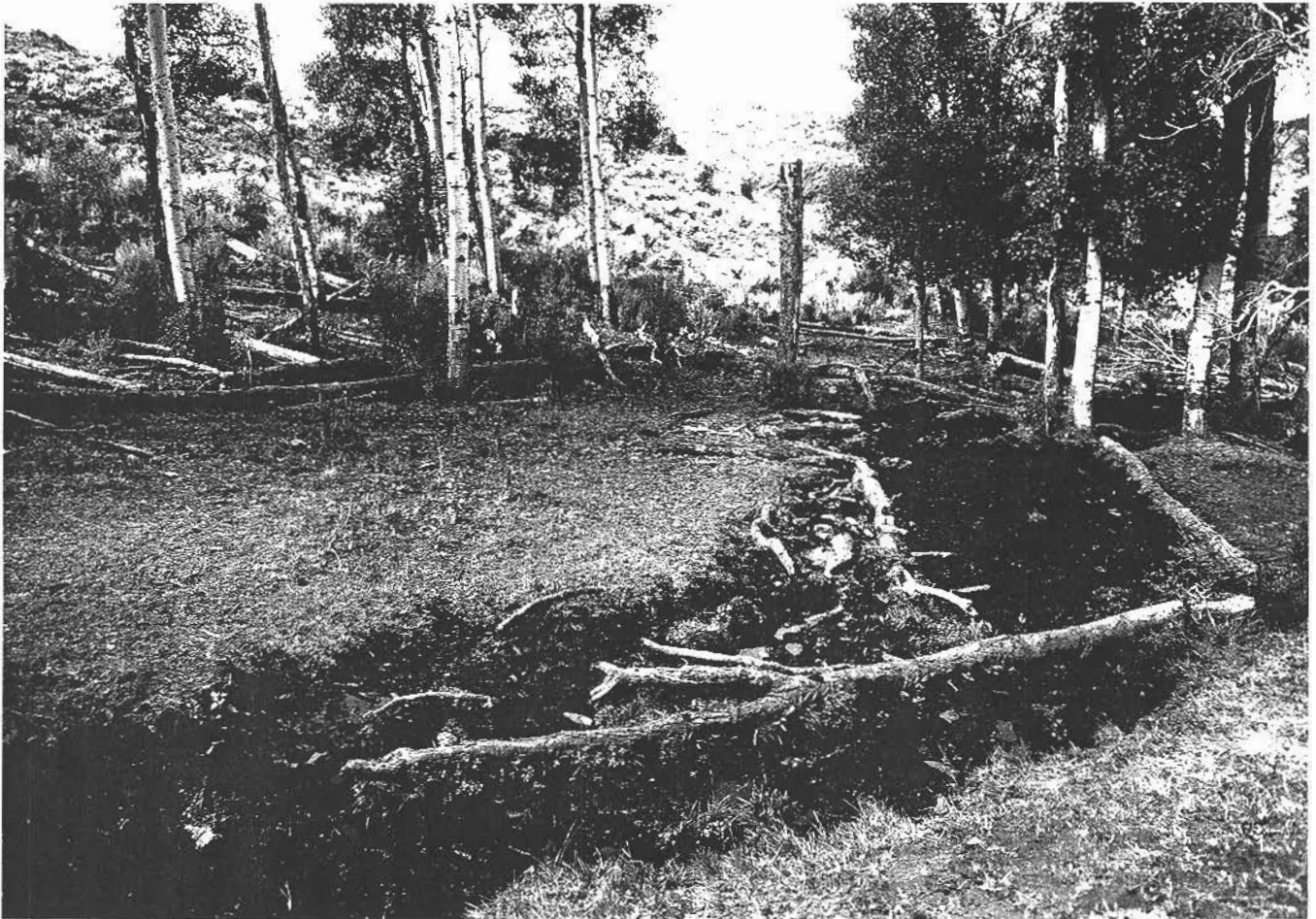


Figure 1. A typical aspen stand in decline on BLM lands, West Fork of Beaver Creek, Elko District. This aspen stand has not successfully regenerated in many years and is in poor ecological condition. All aspen suckers had been repeatedly browsed by cattle. Shown is aspen stand EK-116. Print from color slide by Charles E. Kay; July 27, 2001 (Kay 2002:138).

aspen in central Nevada has not succeeded to sagebrush, but instead has maintained its position in the vegetation association (Kay 2001a, 2002, 2003). Other exclosure studies have found that protected aspen stands have actually expanded and killed-out sagebrush (Kay 1990, 2001b; Kay and Bartos 2000). **Thus, there are no data to support the contention that the decline of aspen in north-central Nevada is due to normal successional processes.**

### Exclosures

**As part of this project, 30 aspen containing exclosures were measured or otherwise evaluated (Table 2). In all cases where aspen has been protected, it successfully regenerated and formed multi-aged stands without fire or other disturbance.** Other aspen exclosure studies in the western U.S. and Canada have reported identical results (Kay 1990, 2001b; Kay et al 1999; Kay and Bartos 2000; and references therein). While apical dominance has been shown to suppress aspen sucker growth (DeByle and Winokur 1985), it does not, in and of itself, prevent aspen stands from successfully producing new stems greater than 6 feet tall, if those clones are protected from herbivory (Figures 2 and 3). **Thus, the single, stem-aged stands found in north-central Nevada and throughout the West today are not a biological attribute of aspen, but the result of excessive ungulate herbivory.** Measurements inside and outside aspen exclosures in Nevada (Kay 2001a, 2002, 2003), as well as elsewhere (Kay 1990, 2001b; Kay et al 1999; Kay and Bartos 2000), also demonstrate

Table 2. Aspen containing exclosures on BLM lands in north-central Nevada

| Exclosure Name         | Date Constructed | Reference          |
|------------------------|------------------|--------------------|
| Elephant Head No. 1    | 1988             | Kay 2001a: 19      |
| Elephant Head No. 2    | 1988             | Kay 2001a: 18      |
| Cottonwood Basin       | 1982             | Kay 2001a: 22      |
| Bates Mountain         | 1965             | Kay 2001a: 29-43   |
| Boone Creek No. 1      | 1990             | Kay 2001a: 74      |
| Boone Creek No. 2      | 1990             | Kay 2001a: 74      |
| Boone Creek No. 3      | 1990             | Kay 2001a: 74      |
| Iowa Creek No. 2       | 1990             | Kay 2001a: 79-85   |
| Iowa Creek No. 3       | 1990             | Kay 2001a: 79-85   |
| Bernd Canyon           | 1992             | Kay 2001a: 88      |
| Billie Creek           | 1996             | Kay 2001a: 103-110 |
| Cottonwood Canyon      | 1982             | Kay 2001a: 128     |
| Beards Canyon          | 1984             | Kay 2002: 22-24    |
| Upper Tonka Springs    | 1985             | Kay 2002: 25-26    |
| Emigrant               | 1994             | Kay 2002: 27-29    |
| Trout Creek No. 2      | 1988             | Kay 2002: 30-32    |
| Trout Creek No. 3      | 1988             | Kay 2002: 30-32    |
| Trout Creek No. 4      | 1988             | Kay 2002: 30-32    |
| Dixie Creek            | 1988             | Kay 2002: 40       |
| Little Porter Creek    | 1988             | Kay 2002: 46-47    |
| Oregon Canoyne         | 1992             | Kay 2002: 96-101   |
| Frazer Canyon          | 1978             | Kay 2002: 102      |
| East Hanks Creek       | 1995             | Kay 2003: 24-31    |
| West Hanks Creek       | 1995             | Kay 2003: 24-31    |
| Antelope Basin         | 1997             | Kay 2003: 24-31    |
| Cheveller              | 1991             | Kay 2003: 45-51    |
| Long Canyon No. 1      | 1986             | Kay 2003: 80-100   |
| Coal Mine Canyon No. 2 | 1985             | Kay 2003: 80-100   |
| Coal Mine Canyon No. 3 | 1985             | Kay 2003: 80-100   |
| Coal Mine Canyon No. 5 | 1985             | Kay 2003: 80-100   |



Figure 2. Aspen regeneration inside the Billie Creek exclosure, Desatoya Mountains, Battle Mountain District. After just 4 years of protection, this clone resprouted at more than 20,000 stems per acre and half those stems were over 6 feet tall. Prior to enclosure, this aspen stand had not regenerated in 150 years due to excessive ungulate herbivory. Understory plants also increased in cover, while bare soil declined. Shown is aspen stand NV-103. Print from color slide by Charles E. Kay; October 7, 2000 (Kay 2001a: 107).

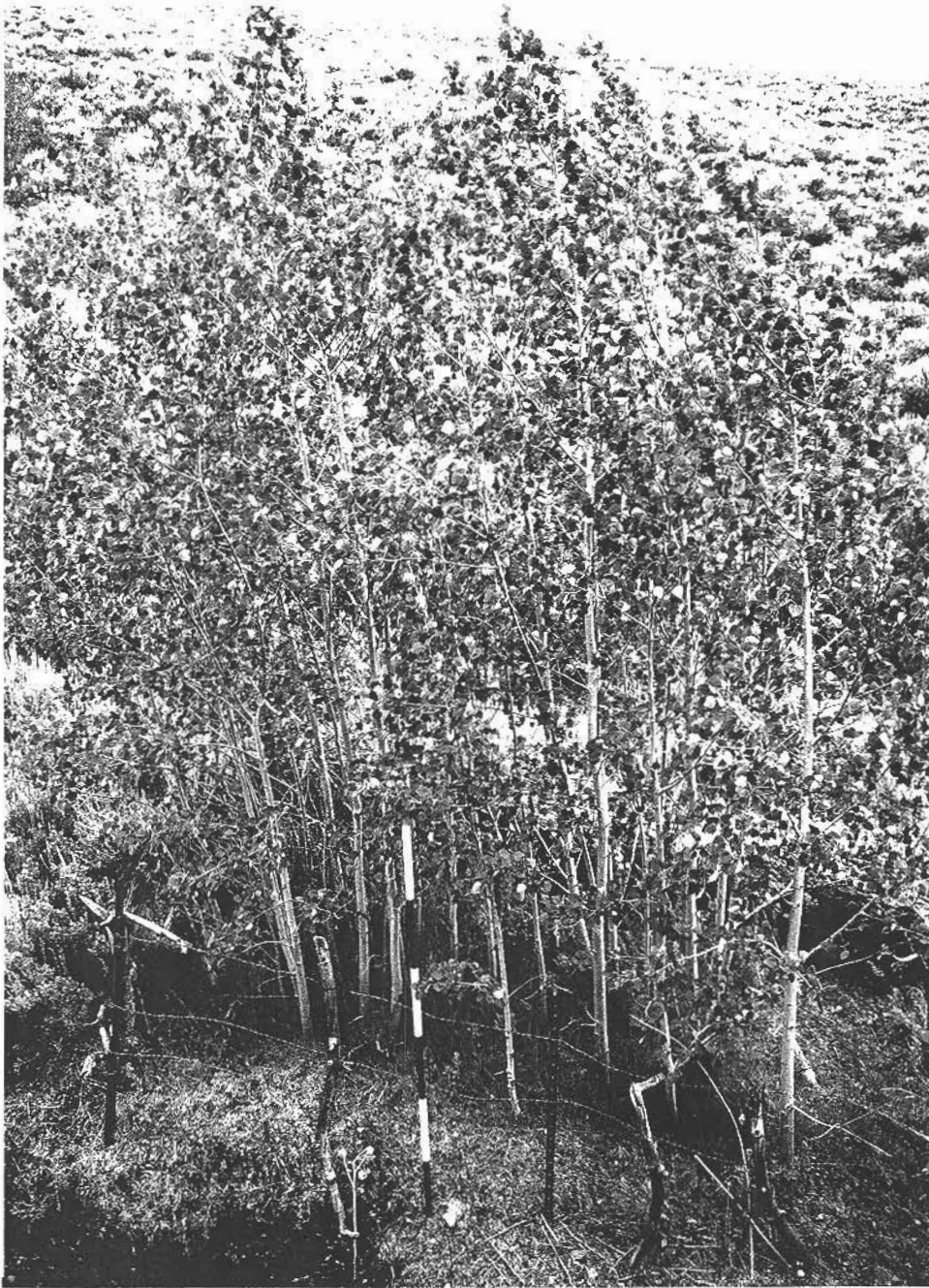


Figure 3. Aspen regeneration inside a small enclosure built by BLM in Oregon Canyon on the Elko District. This enclosure was constructed in 1992, yet the newly regenerated aspen saplings were nearly 20 feet tall in 2001 - - an indication that climate is not limiting aspen growth at this, or any other site, in north-central Nevada. As discussed in the text, all enclosed aspen stands in Nevada successfully produced new stems more than 6 ft. tall without fire, or any other disturbance, once ungulate herbivory was controlled. Aspen sapling density was more than 10,000 stems per acre. Shown is aspen stand EK-84. Red and white survey pole (6 ft.) in one foot sections for scale. Print from color slide by Charles E. Kay; July 16, 2001 (Kay 2002: 101).

that ungulate herbivory, not other factors, largely controls understory species composition. Grazing by elk and mule deer eliminates palatable shrubs and forbs, while livestock use tends to eliminate all palatable species, including grasses (Kay 1990, 2001b; Kay and Bartos 2000). Measurements inside Nevada aspen exclosures showed a much higher canopy cover of palatable shrubs, forbs, and grasses than on adjacent grazed plots (Kay 2001a, 2002, 2003). Conversely, bare soil was more common in grazed areas than inside exclosures (Figures 4 and 5).

**These exclosures also suggest that climate has had little impact on aspen in central Nevada (Kay 2001a, 2002, 2003). In fact, data from across the West has failed to demonstrate a relationship between climatic variation and a corresponding decline in aspen (DeByle and Winokur 1985; Baker et al. 1997; Kay 1997a, 2001, 2001b; White et al. 1998a, 1998b, 2003; Kay and Bartos 2000; Ripple and Larsen 2000; White 2001).** If aspen were declining due to drought or long-term climatic variation, then aspen should also be declining inside exclosures, since the general climate is the same both inside and outside the fenced areas. As that is not the case, we can reject the climatic change hypothesis. Moreover, de facto aspen exclosures exhibit the same trend - - that is, aspen has regenerated whenever it has been protected from ungulate herbivory.

### **De Facto Exclosures**

Ripple and Larson (2001) observed that fallen trees protected aspen suckers from elk use in Yellowstone National Park, while Vera (2000: 132-162) reported that tall, unpalatable shrubs allowed grazing sensitive species to successfully regenerate. By

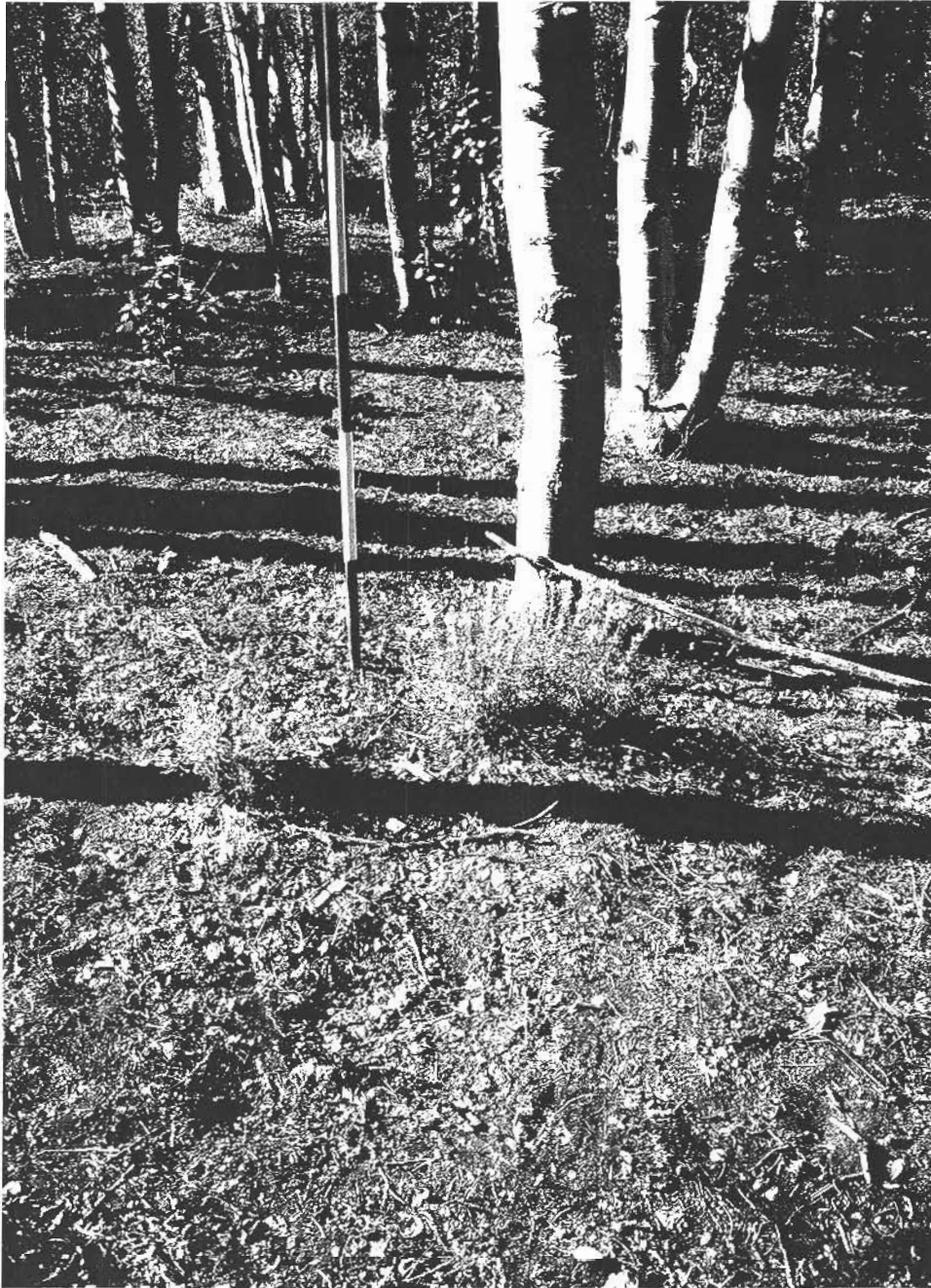


Figure 4. A typical aspen understory outside the Bates Mountain exclosure on the Battle Mountain District. The major cover classes were bare soil (30%) and litter (35%), primarily aspen leaves, while grasses were rare (5%). The lack of understory vegetation is the result of repeated livestock grazing -- compare this with Figure 5 where cattle have been excluded for 35 years. Shown is aspen stand NV-12. Red and white survey pole in one foot segments for scale. Print from color slide by Charles E. Kay; August 20, 2000 (Kay 2001a: 42).



Figure 5. Typical understory vegetation inside the Bates Mountain exclosure on the Battle Mountain District. Unlike aspen understories outside the exclosure, which were primarily leaf litter and bare soil (Figure 4), forbs and grasses had 90% canopy cover inside the exclosure. This difference cannot be attributed to climatic change or other abiotic factors. Although vegetation production was not measured during the present study, plant production inside the exclosure was probably at least 10 times greater than where cattle have grazed for many years, as was the case in 1965 and 1966, shortly after this exclosure was constructed (Tueller and Monroe 1980:92-96). Shown is aspen stand NV-16. Red and white survey pole in one foot segments for scale. Print from color slide by Charles E. Kay; August 20, 2000 (Kay 2001a: 44).

growing within the interlocking branches of fallen aspen trees, or within the interlocking branches of tall, unpalatable shrubs, small isolated groups of aspen stems have been able to successfully regenerate at many sites in north-central Nevada (Figures 6 and 7). **This is another indication that ungulate herbivory, not other factors, is primarily responsible for the decline of aspen seen on BLM lands in Nevada (Kay 2001a, 2002, 2003).**

### **Ungulate Use Data**

**Of the 1,634 pellet groups recorded on aspen belt transects in the Battle Mountain and Elko Districts, 944 (57.8%) were from cattle, 686 (42.0%) from domestic sheep, and 4 (0.2%) from mule deer. In other areas I have worked, the problem has been too many elk (Kay 1997a, 1997c, 2001b, 2001c; White et al. 1998b, 2003) or too many mule deer (Kay and Bartos 2000). In central Nevada, however, domestic livestock are the predominate ungulate herbivore (Kay 2001a, 2002, 2003; Figure 8).** During the course of this study very little mule deer sign was observed anywhere in north-central Nevada, which is not unexpected as mule deer populations in that area have declined since 1990 due to severe winter weather, and only recently began to recover (Dobel 1999). Moreover, except for the Bates Mountain exclosure (Table 2), which is protected by an 8 foot woven-wire fence, all the other exclosures on BLM lands exclude only livestock, not wildlife: i.e., mule deer have access to most central-Nevada exclosures, yet that use has generally been so light, it has not prevented aspen regeneration.

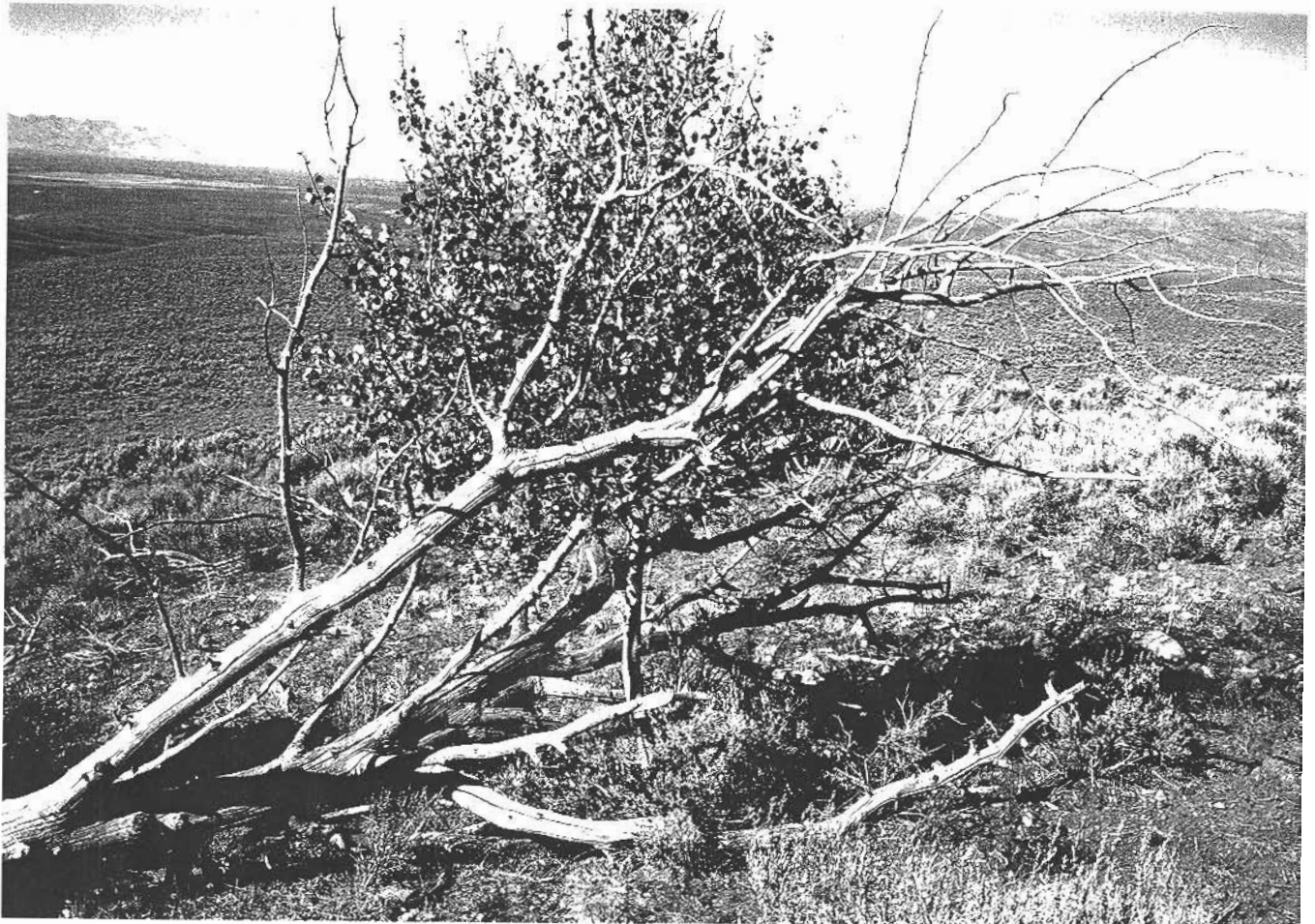


Figure 6. A de facto aspen exclosure on BLM lands in the Adobe Mountains, Elko District. The interlocking branches of the fallen tree (Ripple and Larsen 2001) protected this sucker from repeated cattle use, which allowed that stem to increase in height, until it became a sapling. Such de facto exclosures are common on BLM administered lands in north-central Nevada, an indication that aspen regeneration is controlled by ungulate herbivory, not other factors. Show is aspen stand EK-273. Print from color slide by Charles E. Kay; September 19, 2002 (Kay 2003: 90).



Figure 7. Another type of de facto aspen exclosure on BLM lands in north-central Nevada. Except where physically protected by tall, unpalatable shrubs (Vera 2000:132-162), aspen in this stand has not been able to produce new stems greater than 6 feet in height because all the suckers have been repeatedly browsed. The shrubs in this photograph are big sagebrush (*Artemisia tridentata*) and currant (*Ribes* spp.), both of which are not generally eaten by livestock. Shown is aspen stand EK-131 in the Beaver Creek drainage on the Elko District. Print from color slide by Charles E. Kay; July 28, 2001 (Kay 2002: 151).



Figure 8. A typical aspen sucker on BLM lands in north-central Nevada. On many allotments, all aspen suckers have been repeatedly browsed by livestock, which has prevented height growth and curtailed sapling production. As successful aspen regeneration has been curtailed, aspen stands have declined. The condition of this aspen sucker is not due to climatic change or other abiotic factors. Shown is aspen stand NV-4 in the Shoshone Mountains on the Battle Mountain District. Red and white survey pole in one foot increments for scale. Print from color slide by Charles E. Kay; August 18, 2000 (Kay 2001a: 17).

The fact that Nevada aspen stands on steep slopes far from water are generally in better condition than stands on more gentle slopes near water, is also related to livestock grazing patterns not wildlife use (Kay 2001a, 2002, 2003). In Yellowstone and other national parks where wildlife herbivory is excessive, all aspen stands are heavily grazed and none have successfully regenerated no matter how steep the slope or far from water (Kay 1990).

### **Temporary Livestock Reductions**

**On Bates (Kay 2001a) and Stag Mountains (Kay 2003), major aspen regeneration events occurred when the range was temporarily destocked due to financial difficulties experienced by the grazing permittees.** Stag Mountain is partitioned into two allotments. East of the divide, the range was destocked during the early 1980's when the permittee faced bankruptcy, and during the absence of cattle, most aspen stands successfully produced an abundance of new stems greater than 6 feet tall, without fire or other disturbance (Figure 9). Conversely, the range was never destocked on the west side of Stag Mountain and those aspen have not regenerated in nearly 100 years (Figure 10). **Since climate and wildlife populations are similar throughout the area, aspen's ability, or inability, to successfully regenerate can be attributed to only one factor - - livestock use levels.**



Figure 9. A typical aspen stand on the east side of Stag Mountain on the Elko District. Most aspen stands on this allotment regenerated during the early 1980's when the range was temporarily destocked due to financial difficulties experienced by the grazing permittee. On the adjoining allotment, which was never destocked, aspen has not successfully regenerated in nearly 100 years and is in very poor ecological condition - - see Figure 10. Since both allotments are part of the same mountain range, this difference cannot be due to climatic change or other factors, such as apical dominance. Shown is aspen stand EK-214. Red and white survey pole (6 ft.) for scale. Print from color slide by Charles E. Kay; August 29, 2002 (Kay 2003: 19).



Figure 10. A typical aspen stand on the west side of Stag Mountain, Elko District. Most aspen on this allotment has not successfully regenerated in nearly 100 years and is in poor ecological condition, unlike stands on the adjoining allotment, which experienced a major regeneration during the early 1980's when that range was temporarily destocked due to financial difficulties experienced by the grazing permittee - - compare this with Figure 9. Since both allotments are part of the same mountain range, this difference cannot be due to climatic variation or other factors, such as apical dominance. Shown is aspen stand EK-251. Note the vehicle in the distance for scale. Print from color slide by Charles E. Kay; September 2, 2002 (Kay 2003: 42).

## Fire

It has also been suggested that aspen has declined due to fire suppression by federal and state land management agencies (Houston 1973, 1982; Despain et al. 1986; Romme et al. 1995; Wall et al. 2001). While fire usually has a positive effect on aspen by stimulating root suckering and killing invading conifers, the condition and trend of aspen communities in north-central Nevada are not, in general, related to an absence of fire. If only burned aspen stands were capable of producing new stems greater than 6 feet tall, then aspen inside fenced plots or aspen protected by fallen trees, should not be able to successfully regenerate. **In all cases where aspen was protected from ungulate herbivory in Nevada, however, it has successfully regenerated without fire or other disturbance (Kay 2001a, 2002, 2003), and the same is true throughout the West (White et al. 1998b, 2003; Kay and Bartos 2000; Kay 2001b; White 2001).** Thus, while fire can benefit the species, aspen has not declined solely due to fire suppression. This leaves ungulate herbivory as the main reason aspen has declined in central Nevada, and across the West (Kay 1997a, Kay and Bartos 2000, Ripple and Larsen 2000, White 2001, White et al. 2003).

Fire, in fact, can be very detrimental to aspen if post-burn ungulate herbivory is not controlled. In Jackson Hole and Yellowstone, for instance, repeated elk browsing after fire has prevented sucker height growth and eliminated many aspen stands (Kay 1990, 2001b; and unpublished data following Yellowstone's 1988 wildfires). In Banff National Park, Parks Canada has curtailed its prescribed burning program due, in part, to excessive post-fire use of aspen suckers by elk. **Similarly, in north-central Nevada**

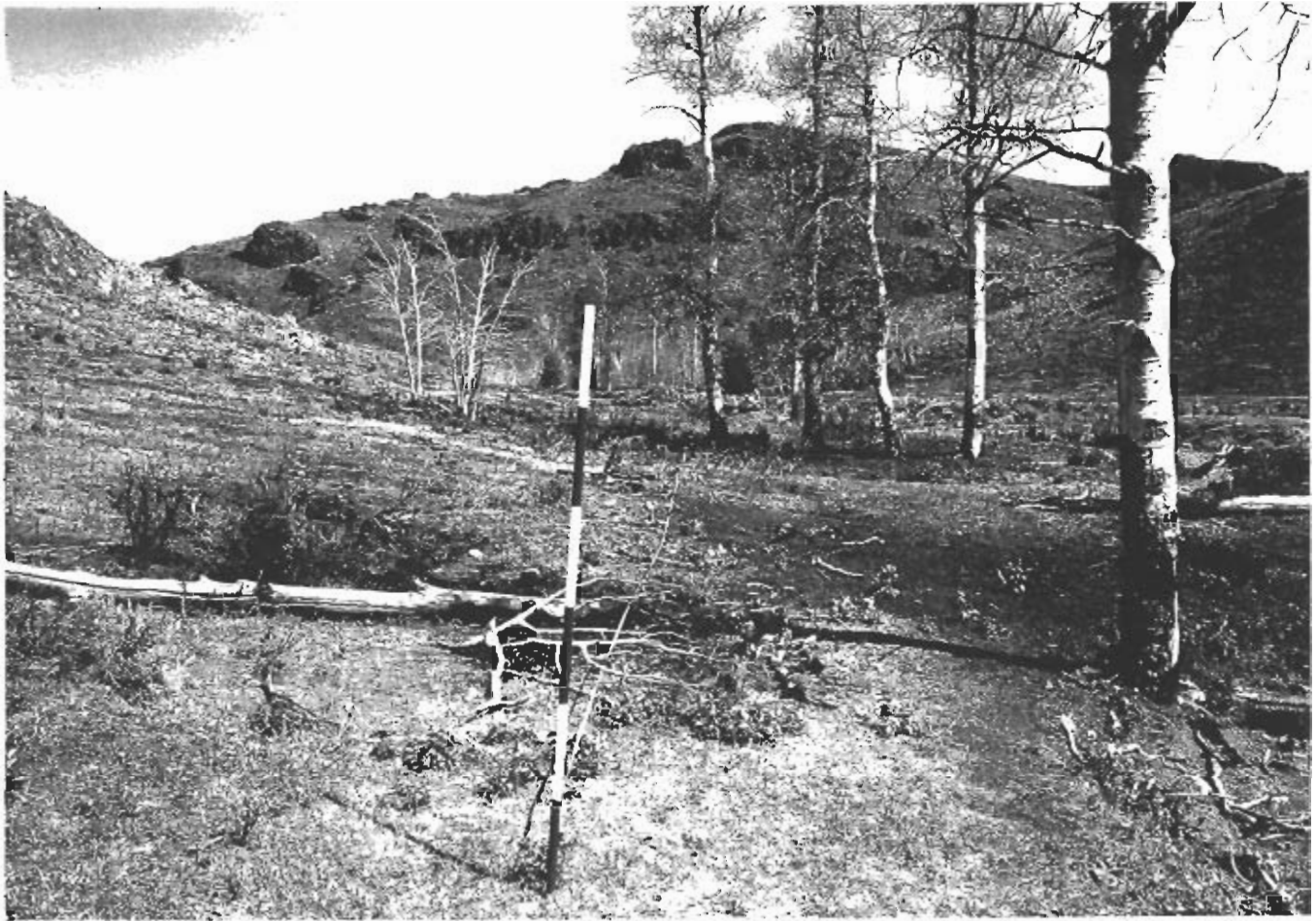


Figure 11. The effect of cattle grazing on aspen regeneration following fire, Stag Mountain, Elko District. This area was swept by wildfire in 2001 and cattle were allowed to graze this allotment in 2002, which severely limited aspen height growth. If such use is allowed to continue, this stand will not successfully regenerate and the clone could be eliminated. This is why browsed aspen stands must be closed to livestock grazing for several years following fire - - compare this with Figure 12, an adjacent burned, but ungrazed stand. Sucker density was 11,122 stems per acre with a mean height of 5.4 inches. Survey pole (6 ft.) for scale. Shown is the belt transect centerline (yellow tape) on plot EK-233. Print from color slide by Charles E. Kay; August 31, 2002 (Kay 2003: 60).



Figure 12. A typical burned, but ungrazed, aspen stand on Stag Mountain, Elko District. This aspen stand is less than 100 yards from that shown in Figure 11, but is ungrazed because it is on the adjoining allotment that was closed to cattle use following the 2001 wildfire. Sucker density in this stand was 49,900 stems per acre, nearly five times that of the adjacent, but grazed site. In addition, these suckers had a mean height of 50.9 inches, which is significantly greater than the 5.4 inches on the adjacent grazed plot. As these adjoining aspen stands are separated only by an allotment fence, these differences cannot be due to climatic variation or other abiotic factors. Unless burned aspen stands are protected for several years, they will not successfully regenerated following fire. Red and white survey pole in one foot increments for scale. Print from color slide by Charles E. Kay; August 31, 2002 (Kay 2003: 61).

**where rangelands have not been rested following wildfire, cattle use has severely reduced aspen sucker height growth.** Two years after a fire swept Sheep Corral Canyon, unbrowsed aspen suckers were more than twice as tall as browsed plants (Kay 2002: 160). While one year following fire on Stag Mountain (Kay 2003), cattle-grazed aspen suckers had a mean height of less than six inches, while adjacent, ungrazed suckers averaged nearly 51 inches tall (Students t test,  $t=4.64$ ,  $p<.001$ ) -- see Figures 11 and 12.

### **Beaver**

Recently, the Bureau of Land Management, the U.S. Forest Service, and others, have transplanted beaver to restore damaged riparian areas (Munther 1982, 1983; Smith 1980, 1983a, 1983b; Kay 1994; Albert and Trimble 2000; Lukas 2000). The Forest Service, for instance, has used beaver to improve wetlands in Montana and Oregon, while BLM initiated beaver-transplant demonstration projects on degraded streams in southwest Wyoming (Johnson 1984, Bergstrom 1985, McKinstry and Anderson 1997, McKinstry et al. 2001). Moreover, other researchers have demonstrated that beaver is a "keystone species" that completely alters the hydrology, energy flow, and nutrient cycling of aquatic systems (Naiman and Melillo 1984; Parker et al. 1985; Naiman et al. 1986, 1988; Platts and Onishuk 1988; Johnston and Naiman 1987, 1990; Smith et al. 1991; Pollock et al. 1995). Beaver dams impound water and trap sediments that raise the water table, increase the wetted perimeter, and allow the extension of riparian communities into former upland sites (Smith 1980, Apple 1983,

McCall et al. 1996). In addition, beaver dams regulate stream flow by storing water, reducing peak or flood flow, and augmenting low flows during summer (Smith 1983b). During dry periods, 30 to 60 percent of the water in a stream system can be held in beaver ponds (Smith 1983a). By trapping silt over thousands of years, beaver dams created many of the West's fertile valleys (Ives 1942). Munther (1982, 1983) reported that a typical creek without beaver furnishes only about two to four acres of riparian habitat per stream mile in the northern Rockies; but with beaver activity, that area can be expanded to twenty-four acres per mile.

Beaver need tall willows or aspen as food and dam-building materials. Aspen and willows cut by beaver normally resprout (Kindschy 1985, 1980) and in turn provide additional food. Once mature aspen trees or tall willows are cut, however, the new suckers are entirely within reach of browsing animals (Kay 1994). By preventing aspen and willows from growing into sizeable plants, ungulate herbivory can eliminate beaver foods and eventually the beaver themselves.

Flook (1964) and Nietvelt (2001) reported that high elk numbers negatively affected beaver through interspecific competition for willows and aspen in Canada's Banff and Jasper National Parks. In Yellowstone National Park, beaver are now ecologically extinct over large areas because the combined action of beaver and excessive elk herbivory has eliminated aspen and willows (Kay 1990, 1994, 1997d; Chadde and Kay 1991; Kay and Walker 1997). Bergerud and Manuel (1968), as well as Collins (1976) noted that high moose (Alces alces) densities had a similar negative effect on beaver in Newfoundland and in Wyoming's Jackson Hole. While others have reported that heavy grazing by domestic livestock reduced woody vegetation, which, in



Figure 13. The effect of beaver and repeated livestock browsing on aspen in north-central Nevada. Shown is an old, beaver-cut aspen stump in stand EK-114 on the Elko District. The area along this tributary to Beaver Creek was a fully-stocked aspen stand until the mature trees were felled by beaver and the new suckers repeatedly browsed by livestock. Although this clone may have maintained its presence on this site for thousands of years, today it is extinct. Red and white survey pole (6 ft.) in one foot segments for scale. Print from color slide by Charles E. Kay; July 27, 2001 (Kay 2002: 137).



Figure 14. The effect of beaver and cattle on aspen along Connors Creek, Elko District. At some point in the past, beaver colonized this area and cut all the aspen along this stream section. Livestock then repeatedly browsed all the new aspen suckers until large areas of aspen were eliminated. This did not happen on the more distant hillsides, which were too far from the stream for beaver to use. The area was subsequently burned by the Stag Mountain fire in 2001. Note the old beaver dam - - photo lower left - - and the vehicle, upstream, for scale. The entire area between the vehicle and the old beaver dam was once a fully stocked aspen stand. This is why all aspen stands with beaver activity must be fenced to exclude livestock. If not, entire clones will be eliminated. Shown is aspen stand EK-231. Print from color slide by Charles E. Kay; August 31, 2002 (Kay 2003: 55).

turn, negatively impacted beaver populations and riparian systems (Platts et al. 1983; Smith and Flake 1983; Dieter 1987; Dieter and McCabe 1989a, 1989b). This is what has happened on the Battle Mountain and Elko Districts. **Aspen + beaver + repeated livestock use eliminated both aspen and beaver, which subsequently caused streams to downcut and erode (Figures 13 and 14).** So, while beaver generally have a positive effect on riparian communities, beaver plus excessive herbivory have the opposite result.

## **MANAGEMENT RECOMMENDATIONS AND GUIDELINES**

**To reverse the decline of aspen on BLM administered lands in north-central Nevada it will be necessary to more closely manage livestock.** Depending on site-specific conditions, it may be necessary to fence some aspen stands, if those clones are to survive. Based on earlier recommendations (Kay 2001a), BLM has already fenced all the aspen stands at Elephant Head in the Shoshone Mountains because those stands were in imminent danger of being lost (Joe Ratliff, personal communication, 2003). In other areas, season-of-use changes may be sufficient to restore aspen. Year-long or season-long grazing is particularly detrimental to aspen, while early-season or dormant-season use may allow aspen to successfully regenerate. That is to say, the timing of grazing can be more important than the intensity (Borman et al. 1999).

As many aspen stands in north-central Nevada are located in riparian settings, it may also be necessary to fence those areas to exclude livestock and to pipe water to

sites some distance from aspen - - of all the springs, seeps, and other water sources observed in north-central Nevada, few were developed and most were heavily grazed by livestock (Clary and Leininger 2000; Kay 2001a, 2002, 2003). AUM reductions may also be necessary on some allotments. In evaluating which measures to implement on what stands, distance to or from water, and the degree of slope are the two most important risk factors (Holechek 1988). Aspen near water is at greater risk than more distant stands and aspen on gentle topography is more at risk than stands on steep slopes - - all other factors being equal - - except on domestic sheep allotments, where upper-elevation aspen stands near bedding areas may also be at risk. Since there is relatively so little aspen on BLM lands in north-central Nevada and because there are no known practical ways of reestablishing aspen (Shepperd and Battaglia 2002: 92), the demise of even a single aspen clone should not be an option, especially since so much has been lost already, at least in some areas.

It is also strongly recommended that BLM establish permanent vegetation sampling plots in aspen communities throughout north-central Nevada to evaluate any management actions the agency might take. One of the most cost effective ways would be to establish a series of permanent photopoints (Magill 1989; Hart and Laycock 1996; Hall 2002a, 2002b). As there are so few long-term, aspen-containing exclosures on BLM lands in the Elko District, all existing aspen exclosures should be retained, and new ones constructed. Just because aspen inside an exclosure has regenerated that does not mean the exclosure should automatically be removed, since the fenced area is still an important range reference area (Laycock 1975).

If fire is used to restore aspen communities, it may be necessary to rest those areas for 1 to 2 years, or longer - - depending on rain fall, prior to treatment to allow fine fuels to accumulate (Brown and Simmerman 1986). Pure aspen stands are very difficult to burn and will usually burn only early in the spring prior to leaf-out or late in the fall after leaf-drop (Brown and Simmerman 1986). If aspen is burned or felled by beaver, it will also be necessary to rest those areas for a minimum of 3 to 5 years to allow the new suckers to grow beyond the reach of grazing animals; i.e. 7 feet tall. In some cases, this could be accomplished with temporary electric fencing. Whatever is done, however, BLM needs to be more vigilant in its monitoring. All fenced areas and exclosures should be checked at least yearly to insure that management goals are being met. BLM may also wish to reconsider its policy of putting gates in some exclosures to prevent those areas from being used as holding pastures. Alternatively, BLM could decide to lock all the gates on its exclosures and provide keys to the grazing permittees so that any cattle, which inadvertently enter the exclosures, could quickly be removed. Grazing permits should specifically state that exclosures are not to be grazed by livestock.

### **Stand Evaluation**

Visual methods can be used as a quick and inexpensive first step in evaluating the condition and trend of aspen communities (Kay 1985, 1990). If, at a distance, you can see through an aspen stand, that generally indicates the clone has not regenerated in many years and is in poor ecological condition (Figure 16). Conversely, if, at a



Figure 15. An example of an aspen stand in good ecological condition, Desatoyo Mountains, Battle Mountain District. Note that you cannot see through the aspen due to the dense growth of aspen saplings - - compare this with Figure 16. Print from color slide by Charles E. Kay; October 7, 2000 (Kay 2001a: Appendix C - - slide No. 843).



Figure 16. An example of a see-through aspen stand in the Beaver Creek drainage on the Elko District. This stand is in poor ecological condition as it has not successfully regenerated in nearly 100 years. Note how you can see completely through the aspen stand because there are no aspen saplings to block the view -- compare this with Figure 15. Print from color slide by Charles E. Kay; July 26, 2001 (Kay 2002: Appendix C -- slide No. 898).

distance, you can not see through an aspen stand, that usually is an indication the clone has produced an abundance of new aspen saplings and is in no immediate danger of extinction (Figure 17). Since aspen does not stagnate like conifers (Perala 1990: 562), researchers have reported a strong linear correlation between stem diameter at breast height (DBH) and stem age (Alder 1970: 15-17; Masslich et al. 1988: 258; Kay 1990: 63, 1997c: 611; this study). Thus, by walking through an aspen stand and estimating, or measuring, stem diameter, you can tell whether the stand is composed of single-aged stems, or if it has successfully regenerated in the recent past. This, of course, can be verified by coring representative aspen with an increment bore (see Methods).

Schenbeck and Dahlsens (1977) recommended circular plots on which to measure aspen stem densities and other parameters, but I (Kay 1990, 1993, 1997c, 2001a, 2001b, 2001c, 2002, 2003; Kay and Bartos 2000) and the U.S. Forest Service (Bartos and Mueggler 1979, 1981; Bartos et al. 1991, 1994; Mueggler 1988, 1989a) recommend 2x30m (6.6 x 98 ft.) belt transects, as they are easier to sample and more representative of conditions within individual aspen stands (see Methods). In practice, it also is very easy to permanently mark and reread aspen belt transects. The transects' beginning and ends are delineated with steel fence posts between which a 30m (100 ft.) tape is stretched (Bartos and Mueggler 1979, 1981; Bartos et al. 1991, 1994). The observer then simply walks down the right side of the tape holding one end of a meter stick against the tape, and recording all stems within one meter of the tape. The process is repeated along the other side of the tape forming a 2 x 30 m belt transect that can be established and read by one person, especially using an Aspen Data Sheet -- see Figure 17.

Figure 17. Aspen data sheet used to record aspen stand parameters on BLM lands in north-central Nevada. Age and stem diameter data are recorded on the back of the sheet along with any other pertinent information (Kay 1990, 1993, 1997c, 2001a, 2001b, 2001c, 2002, 2003; Kay and Bartos 2000).

# Aspen Data Sheet

Location: \_\_\_\_\_ T. \_\_\_\_\_ R. \_\_\_\_\_ S. \_\_\_\_\_

Stand Number: \_\_\_\_\_ Elevation: \_\_\_\_\_ Stand Size: \_\_\_\_\_ Date: \_\_\_\_\_

Visual Estimates: w/Reg. \_\_\_\_\_ w/o Reg. \_\_\_\_\_ w/Conifers \_\_\_\_\_ w/o Conifers \_\_\_\_\_

Aspect: N NE E SE S SW W NW Canopy Cover: \_\_\_\_\_ Photos: \_\_\_\_\_

Barked: Old \_\_\_\_\_ New \_\_\_\_\_ Regeneration >2m hilled \_\_\_\_\_ Conifers hilled \_\_\_\_\_

% of sprouts <2m that are browsed \_\_\_\_\_ Number of old trees in stand \_\_\_\_\_

or which show repeated browsing \_\_\_\_\_

| Transect Section | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 | 18-21 | 21-24 | 24-27 | 27-30 | Total |
|------------------|-----|-----|-----|------|-------|-------|-------|-------|-------|-------|-------|
| <u>Aspen</u>     |     |     |     |      |       |       |       |       |       |       |       |
| <2m              |     |     |     |      |       |       |       |       |       |       |       |
| 2m<              |     |     |     |      |       |       |       |       |       |       |       |
| <5cm             |     |     |     |      |       |       |       |       |       |       |       |
| 6cm-             |     |     |     |      |       |       |       |       |       |       |       |
| 10cm             |     |     |     |      |       |       |       |       |       |       |       |
| 11cm-            |     |     |     |      |       |       |       |       |       |       |       |
| 20cm             |     |     |     |      |       |       |       |       |       |       |       |
| >21cm            |     |     |     |      |       |       |       |       |       |       |       |
| <u>Conifers</u>  |     |     |     |      |       |       |       |       |       |       |       |
| <2m              |     |     |     |      |       |       |       |       |       |       |       |
| 2m<              |     |     |     |      |       |       |       |       |       |       |       |
| <5cm             |     |     |     |      |       |       |       |       |       |       |       |
| 6cm-             |     |     |     |      |       |       |       |       |       |       |       |
| 10cm             |     |     |     |      |       |       |       |       |       |       |       |
| >11cm            |     |     |     |      |       |       |       |       |       |       |       |

Understory Shrubs: \_\_\_\_\_

Canopy Forbs: \_\_\_\_\_

Cover Grasses: \_\_\_\_\_

Estimate \_\_\_\_\_

Community Type: \_\_\_\_\_

## Stem Densities

Schenbeck and Dahlem (1977) recommended 2,100 saplings per hectare, or 850 stems per acre, as a measure of whether or not aspen stands were in acceptable ecological condition. Unfortunately, there is very little scientific data as to what density of aspen saplings is needed to perpetuate an aspen community (Walt Mueggler, personal communication, 2002). BLM has incorporated Schenbeck and Dahlem's (1977) 850 saplings per acre in many of its management plans, but it is important to remember that is a minimum number. **Based on my experience of personally measuring nearly 2,000 aspen stands throughout western North America, I would recommend a somewhat higher figure of 1,500 saplings per acre, especially on areas subject to high levels of ungulate herbivory. In addition, the aspen samplings should be evenly distributed throughout an entire stand or clone.** That is to say, the entire area of the clone should contain aspen saplings. It is not enough for one part of a stand to contain a concentration of aspen saplings, while the rest of the clone has none, as sometimes happens on grazing allotments. The important point is that aspen stands need to produce enough new aspen stems to maintain their long-term presence on the landscape. Multi, stem-aged aspen clones with a fully stocked understory of shrubs, forbs, and grasses have been shown to support higher levels of biodiversity than single, stem-aged stands with a depleted understory (Weatherill and Keith 1969, Page et. al. 1978, Casey and Hein 1983, Oakleaf et al. 1983, Putman et al. 1989, Dailey et al. 1993, Finch and Ruggiero 1993,

Johns 1993, Westworth and Telfer 1993, Stelfox 1995, Grant and Berkey 1999, Kay and Bartos 2000, Kay 2001b).

### **Livestock Use**

**As noted above, aspen is declining on many BLM lands in north-central Nevada because livestock grazing has not been properly managed. Repeated browsing of aspen suckers by livestock is the main reason aspen stands have not successfully regenerated.** Even on allotments where livestock use has been controlled, aspen stands near water may still be in poor ecological condition because cattle tend to concentrate in those areas. Under these conditions, aspen stands must be fenced or the clones will eventually be eliminated.

In western Wyoming where elk are the primary ungulate herbivore and where aspen is declining due to repeated elk use (Kay 2001c), Debyle (1979) suggested that elk populations periodically be reduced to very low levels to allow aspen to recover. This is similar to what has happened on at least two allotments in north-central Nevada when cattle numbers were temporarily reduced due to financial difficulties experienced by the grazing permittees. **Thus, temporary destocking may be another option for improving the condition and trend of aspen communities on BLM lands in Nevada (Sun 2003).** That is to say, if grazing permittees could temporarily move their cattle to other areas for a few years, aspen could be allowed to recover. Something similar to this is now being tried in southern New Mexico, where a large grass bank has been established and on which individual livestock owners can graze their cattle for several

years after fire has been used to improve range conditions on their ranches; i.e., after fire, they do not use their rangelands for several years and, instead, move their cattle on to grass bank lands. According to several observers, the Malpai Borderlands Project has been extremely successful, especially as it is a private organization run by ranchers dedicated to improving rangeland health (Dagget 1995, Hilliard 1996, Jensen 2001, Curtin 2002). Perhaps something similar could be established in Nevada (Anonymous 2003, Cromrich 2003, Sun 2003). In fact, BLM at the national level has proposed several changes in current grazing regulations, including designation of a new type of grazing unit called "Reserve Common Allotments", where permittees could move their livestock while their normal allotments undergo range improvement treatments (Roen 2003, Vetter 2003). Barring such a development, the only way to reverse the decline of aspen on BLM lands in north-central Nevada will be through season of use changes, fencing individual aspen stands, allotment-wide AUM reductions, or complete closures.

## **Fire**

**As explained, fire is not necessary to regenerate aspen stands if ungulate herbivory is controlled, and if ungulate grazing is not controlled, aspen stands should not be burned, as this will only hasten the elimination of those clones (Kay et al. 1999, Kay 2001c).** Many areas of north-central Nevada have been, or will be, swept by wildfire despite the best efforts of BLM and other agencies. Unfortunately, there is no scientific research on how long livestock should be removed after fire to permit burned aspen stands to successfully regenerate (Walt Mueggler, personal

communication, 2002). There is also no data on how numerous, or how tall, aspen suckers need to be following fire before livestock should be allowed on individual allotments (Walt Mueggler, personal communication, 2002). Schenbeck and Dahlen (1977) suggested that aspen suckers be at least 1.5 m (4.9 ft.) tall to avoid damage by cattle. **Based on data collected during this study, as well as observations elsewhere (Kay 2001a), I would recommend a mean sucker height of 7 feet, with a minimum of 10,000 stems per acre. This would be the average height of all aspen suckers on several 2 x 30m belt transects located in different burned aspen stands throughout individual pastures or allotments. On Nevada ranges, this may take 3 to 4 years, or longer, depending on the condition of the aspen stands prior to when they were burned.**

As there is a linear relationship between above and below-ground biomass in aspen stands (Renkin and Despain 1994), and since aspen suckering rates are positively correlated with root biomass (Shepperd 1993, Sheppard and Smith 1993), highly degraded aspen stands will produce fewer aspen suckers following fire than stands in better ecological condition. Thus, allotments on which aspen is in poor condition will likely have to be rested longer, following fire, than ranges that were in better condition, if aspen is to successfully regenerate. Since aspen on many BLM rangelands in north-central Nevada is in poor ecological condition with a downward trend, caution should be used following any wildfires that may, or have already occurred. In no cases should livestock be allowed to graze aspen stands that have not been sufficiently rested after being overrun by wildfire.

## Beaver and Aspen

**Based on data collected during this study, as well as other observations across the West (Kay 1994, Nietvelt 2001), if beaver colonize aspen-lined streams in north-central Nevada, those areas should immediately be fenced to exclude livestock or those clones will eventually be lost.** As already discussed, beaver plus aspen plus repeated ungulate herbivory usually leads to the elimination of both aspen and beaver. As many streams in central Nevada are also home to various endangered fish, such as Lahontan cutthroat trout (Oncorhynchus clarki henshawii), livestock should be excluded from all areas where beaver are actively cutting aspen, and those fences maintained until the new aspen suckers are well beyond the reach of livestock, or streamside cover will permanently be lost, with a correspondingly negative impact on aquatic organisms.

## LITERATURE CITED

- Albert, S., and T. Trimble. 2000. Beavers are partners in riparian restoration on the Zuni Indian Reservation. *Ecological Restoration* 18:87-92.
- Alder, G.M. 1970. Age profiles of aspen forests in Utah and northern Arizona. M.A. Thesis, University of Utah, Salt Lake City, UT. 31 pp.
- Anonymous. 2003. Grassbank adds value - - and options. *Rangelands* 25 (1):27.
- Apple, L.L. 1983. The use of beavers in riparian/aquatic habitat restoration in a cold desert gully-cut stream system: A case history. *Proceedings of the American Fisheries Society* 18:29-35.
- Baker, F.S. 1918. Aspen reproduction in relation to management. *Journal of Forestry* 16:389-398.
- Baker, F.S. 1925. Aspen in the central Rocky Mountain region. U.S. Department of Agriculture Bulletin No. 1291. 47 pp.
- Baker, W.L., J. A. Monroe, and A.E. Hessel. 1997. The effects of elk on aspen in the winter range in Rocky Mountain National Park. *Ecography* 20:155-165.
- Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Pages 59-80 in Smith, D.R., ed. Symposium on management of forest and range habitats for nongame birds. U.S. Forest Service General Technical Report WO-1.
- Bartos, D.L., and R.B. Campbell, Jr. 1998. Decline of quaking aspen in the interior west - - examples from Utah. *Rangelands* 20:17-24.
- Bartos, D.L., and W.F. Mueggler. 1979. Influence of fire on vegetation production in the aspen ecosystem in western Wyoming. Pages 75-78 in Boyce, M.S. and

L.D. Hayden-Wing, eds. North American elk: Ecology, behavior and management. University of Wyoming, Laramie, WY. 294 pp.

Bartos, D.L., and W.F. Mueggler. 1981. Early succession in aspen communities following fires in western Wyoming. *Journal of Range Management* 34:315-318.

Bartos, D.L., J.K. Brown, and G.D. Booth. 1994. Twelve years biomass response in aspen communities following fire. *Journal of Range Management* 47:79-83.

Bartos, D.L., W.F. Mueggler, and R.B. Campbell Jr. 1991. Regeneration of aspen by suckering on burned sites in western Wyoming. U.S. Forest Service Research Paper INT-448. 10 pp.

Beck, J.L., and J.M. Peek. 2001. Jarbridge cooperative elk herd carrying capacity study - - 1999 annual report: Preliminary estimates of 1999 elk summer range carrying capacity. Idaho Bureau of Land Management Technical Bulletin No. 01-3. 32 pp.

Bergerud, A.T., and F. Manuel. 1968. Moose damage to balsam fir-white birch forests in central Newfoundland. *Journal of Wildlife Management* 32:729-746.

Bergstrom, D. 1985. Beavers: Biologists "rediscover" a natural resource. *Forestry Research West* (Oct.): 1-5.

Borman, M.M., C.R. Massingill, and E.W. Elmore. 1999. Riparian area responses to changes in management. *Rangelands* 21:3-7.

Brown, J.K., and D.G. Simmerman. 1986. Appraisal of fuels and flammability in western aspen: A prescribed fire guide. U.S. Forest Service General Technical Report INT-205. 48 pp.

- Cartwright, C.W., Jr., and D.P. Burns. 1994. Sustaining our aspen heritage into the twenty-first century. U.S. Forest Service, Southwestern Region. 6 pp.
- Casey, D., and D. Hein. 1983. Effects of heavy browsing on a bird community in deciduous forest. *Journal of Wildlife Management* 47:829-836.
- Chadde, S.W., and C.E. Kay. 1991. Tall willow communities on Yellowstone's northern range: A test of the "natural regulation" paradigm. Pages 231-264 in Keiter, R.R., and M.S. Boyce, eds. *The Greater Yellowstone Ecosystem: Redefining American's wilderness heritage*. Yale University Press, New Haven, CT. 428 pp.
- Clary, W.P., and W.C. Leininger. 2000. Stubble height as a tool for management of riparian areas. *Journal of Range Management* 53:562-573.
- Coles, F.H. 1965. The effects of big game and cattle grazing on aspen regeneration. M.S. Thesis, Brigham Young University, Provo, UT. 72 pp.
- Collins, T.C. 1976. Population characteristics and habitat relationships of beaver, Castor canadensis, in northwest Wyoming. Ph.D. Dissertation, University of Wyoming, Laramie, WY. 192 pp.
- Cromrich, L. 2003. Healing the sagebrush sea. *Bugle* 20 (2):40-51.
- Curtin, C.G. 2002. Integration of science and community-based conservation in the Mexico/U.S. border lands. *Conservation Biology* 16:880-886.
- Dagget, D. 1995. Beyond the rangeland conflict: Toward a West that works. The Grand Canyon Trust, Flagstaff, AZ and Gibbs Smith, Publisher, Layton, UT. 104 pp.
- Daily, G.C., P.R. Ehrlich, and N.M. Haddad. 1993. Double keystone bird in a keystone species complex. *Proceedings of the National Academy of Science* 90:592-594.

- DeByle, N.V. 1979. Potential effects of stable versus fluctuating elk populations in the aspen ecosystem. Pages 13-19 in Boyce, M.S., and L.D. Hayden-Wing, eds. North American elk: Ecology, behavior and management. University of Wyoming, Laramie, WY. 294 pp.
- DeByle, N.V., C.D. Bevins, and W.C. Fisher. 1987. Wildfire occurrence in aspen in the interior western United States. *Western Journal of Applied Forestry* 2:73-76.
- DeByle, N.V., and R.P. Winokur, eds. 1985. Aspen: Ecology and management in the western United States. U.S. Forest Service General Technical Report RM-119. 283 pp.
- Despain, D., D. Houston, M. Meagher, and P. Schullery. 1986. Wildlife in transition: Man and nature on Yellowstone's northern range. Roberts Rinehart, Boulder, CO. 142 pp.
- Dieter, C.D. 1987. Habitat use by beaver along the Big Sioux River. M.S. Thesis, South Dakota State University, Brookings, SD. 60 pp.
- Dieter, C.D., and T.R. McCabe. 1989a. Factors influencing beaver lodge-site selection on a prairie river. *American Midland Naturalist* 122:408-411.
- Dieter, D.D., and T.R. McCabe. 1989b. Habitat use by beaver along the Big Sioux River in eastern South Dakota. Pages 135-140 in Gresswell, R.E., B.A. Barton, and J.L. Kershner, eds. Practical approaches to riparian management: An educational workshop. Bureau of Land Management, Montana State Office BLM-MT-PT-89-0001-4351. 193 pp.
- Dobel, M. 1999. Estimating Nevada's deer herds. *Nevada Wildlife Almanac* (Fall-Winter):6.

- Ehrlich, P.R., and G.C. Daily. 1993. Birding for fun: Sapsuckers, swallows, aspen, and rot. *American Birds* 47(1):18-20.
- Endersby, H. 1999. The aspen-mule deer link. *Mule Deer* 4(2):16-19.
- Fechner, G.H., and J.S. Barrows. 1976. Aspen stands as wildfire fuelbreaks. *Eisenhower Consortium Bulletin* 4:1-26. U.S. Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
- Finch, D.M., and L.F. Ruggiero. 1993. Wildlife habitats and biological diversity in the Rocky Mountains and northern Great Plains. *Natural Areas Journal* 13:191-203.
- Flack, J.A.D. 1976. Bird populations of aspen forests in western North America. *Ornithological Monograph No. 19*. 97 pp.
- Flook, D.R. 1964. Range relationships of some ungulates native to Banff and Jasper National Parks, Alberta. Pages 119-128 in D.J. Crisp, ed. *Grazing in terrestrial and marine environments*. Blackwell Press, Oxford, UK. 429 pp.
- Grant, M.C. 1993. The trembling giant. *Discover* 14(10):82-89.
- Grant, T.A., and G.B. Berkey. 1999. Forest area and avian diversity in fragmented aspen woodland of North Dakota. *Wildlife Society Bulletin* 27:904-914.
- Gruell, G.E., and L.L. Loope. 1974. Relationships among aspen, fire and ungulate browsing in Jackson Hole, Wyoming. U.S. Forest Service Intermountain Region, Ogden, UT. 33 pp.
- Hall, F.C. 2002a. Photo point monitoring handbook: Part A - - Field procedures. U.S. Forest Service General Technical Report PNW-GTR-526. 48 pp.
- Hall, F.C. 2002b. Photo point monitoring handbook: Part B - - Concepts and analysis. U.S. Forest Service General Technical Report PNW-GTR-526. 86 pp.

- Hart, R.H., and W.A. Laycock. 1996. Repeat photography on range and forest lands in the western United States. *Journal of Range Management* 49:60-67.
- Hilliard, G. 1996. A hundred years of horse tracks - - the story of the Gray Ranch. High-Lonesome Books, Silver City, NM. 176 pp.
- Holechek, J.L. 1988. An approach for setting the stock rate. *Rangelands* 10:10-14.
- Houston, D.B. 1973. Wild fires in northern Yellowstone National Park. *Ecology* 54:1111-1117.
- Houston, D.B. 1982. The northern Yellowstone elk: Ecology and management. MacMillan Publishers, New York, NY. 474 pp.
- Ives, R.L. 1942. The beaver-meadow complex. *Journal of Geomorphology* 5:191-203.
- Jelinski, D.E., and W.M. Cheliak. 1992. Genetic diversity and spatial subdivision of Populus tremuloides (Salicaceae) in a heterogenous landscape. *American Journal of Botany* 79:728-736.
- Jenson, M.N. 2001. Can cows and conservation mix? *Bioscience* 51:85-90.
- Johns, B.W. 1993. The influence of grove size on bird species richness in aspen parklands. *Wilson Bulletin* 105:256-264.
- Johnson, M.A. 1994. Changes in southwestern forests: Stewardship implications. *Journal of Forestry* 92(12):16-19.
- Johnson, P. 1984. The dam builder is at it again! *National Wildlife* (June-July): 9-15.
- Johnston, C.A., and R.J. Naiman. 1987. Boundary dynamics at the aquatic-terrestrial interface: The influence of beaver and geomorphology. *Landscape Ecology* 1:47-57.

- Johnston, C.A., and R.J. Naiman. 1990. The use of a geographic information system to analyze long-term landscape alteration by beaver. *Landscape Ecology* 4:5-19.
- Kay, C.E. 1985. Aspen reproduction in the Yellowstone Park-Jackson Hole area and its relationship to the natural regulation of ungulates. Pages 131-160 in Workman, G.W., ed. *Western elk management: A symposium*. Utah State University, Logan, UT. 213 pp.
- Kay, C.E. 1990. Yellowstone's northern elk herd: A critical evaluation of the "natural regulation" paradigm. Ph.D. Dissertation, Utah State University, Logan, UT. 490 pp.
- Kay, C.E. 1993. Aspen seedlings in recently burned areas in Grand Teton and Yellowstone National Parks. *Northwest Science* 67:94-104.
- Kay, C.E. 1994. The impact of native ungulates and beaver on riparian communities in the Intermountain West. *Natural Resources and Environmental Issues* 1:23-44.
- Kay, C.E. 1997a. Is aspen doomed? *Journal of Forestry* 95(5):4-11.
- Kay, C.E. 1997b. Aspen: A new perspective - - implications for park management and ecological integrity. Pages 265-273 in Harmon, D., ed. *Marking protection work: Proceedings of the 9<sup>th</sup> conference on research and resource management in parks and on public lands*. The George Wright Society, Hancock, MI. 493 pp.
- Kay, C.E. 1997c. The condition and trend of aspen, Populus tremuloides, in Kootenay and Yoho National Parks: Implications for ecological integrity. *Canadian Field-Naturalist* 111:607-616.
- Kay, C.E. 1997d. Viewpoint: Ungulate herbivory, willows, and political ecology in Yellowstone. *Journal of Range Management* 50:139-145.

- Kay, C.E. 1997e. Yellowstone: Ecological malpractice - - photo excerpts from a forthcoming book. PERC Reports 15(2):1-40.
- Kay, C.E. 1999. Repeat photography and long-term vegetational change on the U.S. Sheep Experiment Station and other rangelands in the Centennial Mountains. Final report to U.S. Sheep Experiment Station, Dubois, ID. 300 pp.
- Kay, C.E. 2000. Native burning in western North America: Implications for hardwood management. Pages 19-27 in Yaussy, D.A., ed. Proceedings: Workshop on fire, people, and the central hardwood landscape. U.S. Forest Service General Technical Report NE-274. 129 pp.
- Kay, C.E. 2001a. The condition and trend of aspen communities on BLM administered lands in central Nevada - - Final report to BLM Battle Mountain Field Office, 50 Bastian Road, Battle Mountain, Nevada, 89820. 155 pp + Appendices.
- Kay, C.E. 2001b. Long-term aspen exclosures in the Yellowstone Ecosystem. Pages 225-240 in Shepperd, W.D., D. Binkley, D.L. Bartos, T.J. Stohlgren, and L.G. Eskew, eds. Sustaining aspen in western landscapes. U.S. Forest Service Proceedings RMRS-P-18. 460 pp.
- Kay, C.E. 2001c. Evaluation of burned aspen communities in Jackson Hole, Wyoming. Pages 215-223 in Shepperd, W.D., D. Binkley, D.L. Bartos, T.J. Stohlgren, and L.G. Eskew, eds. Sustaining aspen in western landscapes. U.S. Forest Service Proceedings RMRS-P-18. 460 pp.
- Kay, C.E. 2002. The condition and trend of aspen communities on BLM administered lands in the north-central Nevada - - with recommendations for management.

Final report to BLM Elko Field Office, 3900 East Idaho Street, Elko, Nevada, 89801. 193 pp. + Appendices.

Kay, C.E. 2003. The condition and trend of aspen on BLM lands in north-central Nevada - - with recommendations for management - - year three. Final report to BLM Elko Field Office, 3900 East Idaho Street, Elko, Nevada, 89801. 131 pp. + Appendices.

Kay, C.E., C.A. White, I.R. Pengelly, and B. Patton. 1999. Long-term ecosystem states and processes in Banff National Park and the central Canadian Rockies. Parks Canada Occasional Paper No. 9, Environment Canada, Ottawa, ON.

Kay, C.E., and D.L. Bartos. 2000. Ungulate herbivory on Utah aspen: Assessment of long-term exclosures. *Journal of Range Management* 53:145-153.

Kay, C.E., and F.H. Wagner. 1994. Historic condition of woody vegetation on Yellowstone's northern range: A critical test of the "natural regulation" paradigm. Pages 151-169 in Despain, D.G., ed. *Plants and their environments'* - - Proceeding of the first biennial scientific conference on the Greater Yellowstone Ecosystem. U.S. National Park Service, Denver, CO. Technical Report NPS/NRYELL/NRTR-93/XX. 347 pp.

Kay, C.E., and F.H. Wagner. 1996. The response of shrub-aspen to Yellowstone's 1988 wildfires: Implications for "natural regulation" management. Pages 107-111 in Greenlee, J.M., ed. *Ecological implications of fire in Greater Yellowstone: Proceedings of the second biennial conference on the Greater Yellowstone Ecosystem*. International Association of Wildland Fire, Fairfield, WA. 235 pp.

- Kay, C.E., and J.W. Walker. 1997. A comparison of sheep and wildlife grazed willow communities in the Greater Yellowstone Ecosystem. *Sheep and Goat Research Journal* 13:6-14.
- Kennedy, T.B., A.M. Merenlender, and G.L. Vinyard. 2000. A comparison of riparian condition and aquatic invertebrate community indices in central Nevada. *Western North American Naturalist* 60:255-272.
- Kindschy, R.R. 1985. Response of red willow to beaver use in southeastern Oregon. *Journal of Wildlife Management* 49:26-28.
- Kindschy, R.R. 1989. Regrowth of willow following simulated beaver cutting. *Wildlife Society Bulletin* 17:290-294.
- Krebill, R.G. 1972. Mortality of aspen on the Gros Ventre elk winter range. U.S. Forest Service Research Paper INT-129. 16 pp.
- Laycock, W.A. 1975. Rangeland reference areas. Society for Range management, Range Science Series No. 3. 34 pp.
- Loope, L.L., and G.E. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. *Quaternary Research* 3:425-443.
- Lukas, D. 2000. Movers of the Earth. *Audubon* 102(2):29-33.
- Magill, A.W. 1989. Monitoring environmental change with color slides. U.S. Forest Service General Technical Report PSW-117. 55 pp.
- Masslich, W.J., J.D. Brotherson, and R.G. Cates. 1988. Relationship of aspen (Populus tremuloides) to foraging patterns of beaver (Castor Canadensis) in the Strawberry Valley of central Utah. *Great Basin Naturalist* 48:250-262.

- McCall, T.C., T.P. Hodgman, D.R. Diefenbach, and R.B. Owen, Jr., 1996. Beaver populations and their relation to wetland habitat and breeding waterfowl in Maine. *Wetlands* 16:163-172.
- McDonough, W.T. 1979. Quaking aspen seed germination and early seedling growth. U.S. Forest Service Research Paper INT-234. 13 pp.
- McDonough, W.T. 1985. Sexual reproduction, seeds and seedlings. Pages 25-28 in N.V. DeByle, and R.P. Winokur, eds. *Aspen: Ecology and management in the western United States*. U.S. Forest Service General Technical Report RM-119. 283 pp.
- McKinstry, M.C., P. Caffrey, and S.H. Anderson. 2001. The importance of beaver to wetland habitats and waterfowl in Wyoming. *Journal of the American Water Resources Association*. 37:1571-1577.
- McKinstry, M.C. and S.H. Anderson. 1997. Use of Beaver to improve riparian areas in Wyoming. Pages 128-134 in Goertler, C., C. Rumsey, T. Bray, and D. Boysen, eds. *Wyoming water 1997: Applied research for management of Wyoming's water resources*. Wyoming Water Research Center, Laramie, WY.
- Mitton, J.B. and M.C. Grant. 1996. Genetic variation and the natural history of quaking aspen. *Bioscience* 46:25-31.
- Mueggler, W.F. 1988. Aspen community types of the Intermountain region. U.S. Forest Service General Technical Report INT-250. 135 pp.
- Mueggler, W.F. 1989a. Age distribution and reproduction of Intermountain aspen stands. *Western Journal of applied Forestry* 4:41-45.

- Mueggler, W.F. 1989b. Status of aspen woodlands in the West. Pages 32-37 in Pendleton, B.G., ed. Western raptor management symposium and workshop. National Wildlife Federation Scientific and Technical Series No. 12. Washington, D.C.
- Munther, G.L. 1982. Beaver management in grazed riparian ecosystems. Pages 234-241 in Proceedings of the wildlife-livestock relationships symposium. University of Idaho Forest, Wildlife and Range Experiment Station, Moscow, ID.
- Munther, G.L. 1983. Integration of beaver into forest management. Paper presented at Colorado-Wyoming Chapter of the American Fisheries Society, Laramie, WY. 8 pp.
- Naiman, R.J., and J.M. Melillo. 1984. Nitrogen budget of a subarctic stream altered by beaver (Castor canadensis). *Oecologia* 62:150-155.
- Naiman, R.J., J.M. Melillo, and J.E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (Castor canadensis). *Ecology* 67:1254-1269.
- Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by beaver. *Bioscience* 38:753-762.
- Nelson, J.R., and T.A. Leege. 1982. Nutritional requirements and food habits. Pages 323-367 in Thomas, J.S., and D.E. Toweill, eds. *Elk of North America: Ecology and management*. Stackpole Books, Harrisburg, PA. 698 pp.
- Nietvelt, C.G. 2001. Herbivory interactions between beaver (Castor Canadensis) and elk (Cervus elaphus) on willow (Salix spp.) in Banff National Park, Alberta. M.S. Thesis, University of Alberta, Edmonton, AB. 117 pp.

- Oakleaf, R.F., C. Masser, and T. Nappe. 1983. Livestock and nongame wildlife. Pages 95-102 in Menke, J.W., ed. Proceedings of the workshop on livestock and wildlife-fisheries relationships in the Great Basin. University of California Special Publications 3301. 173 pp.
- Olmsted, C.E. 1977. The effect of large herbivores on aspen in Rocky Mountain National Park. Ph.D. Dissertation, University of Colorado, Boulder, CO. 136 pp.
- Olmsted, C.E. 1979. The ecology of aspen with reference to utilization by large herbivores in Rocky Mountain National Park. Pages 89-97 in Boyce, M.S., and L.D. Hayden-Wing, eds. North American elk: Ecology, behavior, and management. University of Wyoming, Laramie, WY. 294 pp.
- Olmsted, C.E. 1997. Twenty years of change in Rocky Mountain National Park winter range aspen. Technical Report. Environmental Studies Program, University of Northern Colorado, Greeley, CO. 41 pp.
- Page, J.L., N. Dodd, T.O. Osborne, and J.A. Carson. 1978. The influence of livestock grazing on non-game wildlife. California-Nevada Wildlife 1978:159-173.
- Parker, M., F.J. Wood, Jr., B.H. Smith, and R.G. Elder. 1985. Erosional downcutting in lower order ecosystems: Have historical changes been caused by removal of beaver? Pages 35-38 in Johnson, R.R., C.D. Ziebell, D.R. Patton, P.F. Ffolliott, and R.H. Hamre, eds. Riparian ecosystems and their management: Reconciling conflicting uses. U.S. Forest Service General Technical Report RM-120.
- Perala, D.A. 1990. Quaking aspen. Pages 555-569 in Burns, R.M., and B.H. Honkala, eds. Silvics of north America. Volume 2. hardwoods. U.S. Department of Agriculture, Agriculture Handbook 654.

- Peterson, E.B., and N.M. Peterson. 1992. Ecology, management and use of aspen and balsam poplar in the prairie provinces, Canada. Forestry Canada Northern Forest Center Special Report 1. 252 pp.
- Peterson, E.B., and N.M. Peterson. 1995. Aspen managers' handbook for British Columbia. British Columbia Ministry of Forests and Canadian Forest Service. FRDA Report 230. 110 pp.
- Platts, W.S., and M. Onishuk. 1988. "Good" beavers, "bad" beavers. Idaho Wildlife 41(2):23-27.
- Platts, W.S., R.L. Nelson, O. Casey, and V. Crispin. 1983. Riparian-stream habitat conditions on Tabor Creek, Nevada, under grazed and ungrazed conditions. Western Association of Fish and Wildlife Agencies 63:162-174.
- Pollock, M.M., R.J. Naiman, H.E. Erickson, C.A. Johnston, J. Pastor, and G. Pinay. 1995. Beaver as engineers: Influences on biotic and abiotic characteristics of drainage basins. Pages 117-126 in Jones, C.G., and J.H. Lawton, eds. Linking species and ecosystems. Chapman and Hall, New York, NY. 387 pp.
- Putman, R.J., P.J. Edwards, J.C.E. Mann, R.C. How, and S.D. Hill. 1989. Vegetational and faunal changes in an area of heavily grazed woodland following relief of grazing. Biological Conservation 47:13-32.
- Renkin, R., and D. Despain. 1994. Suckering in burned aspen as related to above-ground and below-ground biomass. Pages 341-344 in Despain, D.G., ed. Plants and their environments: Proceedings of the first biennial scientific conference on the Greater Yellowstone Ecosystem. U.S. National Park Service, Natural

Resources Publication office, Denver, CO. Technical Report

NPS/NRYELL/NRTR – 93/XX. 347 pp.

Ripple, W.J., and E.J. Larson. 2000. Historic aspen recruitment, elk, and wolves in northern Yellowstone National Park, USA. *Biological Conservation*: In press.

Ripple, W.J., and E.J. Larsen. 2001. The role of postfire coarse woody debris in aspen regeneration. *Western Journal of Applied Forestry* 16:61-64.

Roen, S.L. 2003. BLM considers changes to grazings regs. *Western Livestock Journal* 82(17)1,6.

Romme, W.H., M.G. Turner, L.L. Wallace, and J.S. Walker. 1995. Aspen, elk, and fire in northern Yellowstone National Park. *Ecology* 76:2097-2106.

Sampson, A.W. 1919. Effect of grazing upon aspen reproduction. U.S. Department of Agriculture Bulletin No. 741. 29 pp.

Schenbeck, G.L., and E.A. Dahlem. 1977. Proposed management of aspen habitat in northern Nevada. *California-Nevada Wildlife* 1977:68-74.

Schier, G.A. 1975. Deterioration of aspen clones in the middle Rocky Mountains. U.S. Forest Service Research Paper INT-170. 14 pp.

Schier, G.A., and R.B. Campbell. 1980. Variation among healthy and deteriorating aspen clones. U.S. Forest Service Research Paper INT-264. 12 pp.

Shepperd, W.D. 1993. Initial growth, development, and clonal dynamics of regenerated aspen in the Rocky Mountains. U.S. Forest Service Research Paper RM-312.

- Shepperd W.D., and F.W. Smith. 1993. The role of near-surface lateral roots in the life cycle of aspen in the central Rocky Mountains. *Forest Ecology and Management* 61:157-170.
- Shepperd, W.D., and M.A. Battaglia. 2002. Ecology, silviculture, and management of Black Hills ponderosa pine. U.S. Forest Service General Technical Report RMRS-GTR-97. 112 pp.
- Shepperd, W.D., and M.L. Fairweather. 1994. Impact of large ungulates in restoration of aspen communities in a southwestern ponderosa pine ecosystem. Pages 344-347 in Covington, W.S., and L.F. DeBano, eds. *Sustainable ecological systems: Implementing an ecological approach to land management*. U.S. Forest Service General Technical Report RM-247. 363 pp.
- Smith, B.H. 1980. Not all beaver are bad; or, an ecosystem approach to stream habitat management, with possible software applications. Pages 32-36 in *Proceedings of the 15<sup>th</sup> annual meeting of the Colorado-Wyoming Chapter of the American Fisheries Society*.
- Smith, B.H. 1983a. Riparian willow management: Its problems and potentials, within the scope of multiple use on public lands. Pages 15-20 in *Proceedings of the Ninth Wyoming Shrub Ecology Workshop*, Lander, Wyoming.
- Smith, B.H. 1983b. Restoration of riparian habitats within the BLM-Rock Springs District. Paper presented at *Wildlife Habitat Rehabilitation and Reclamation Symposium*. January 10-11. Salt Lake City, UT. 8 pp.
- Smith, M.E., C.T. Driscoll, B.J. Wyskowski, C.M. Brooks, and C.C. Cosentini. 1991. Modification of stream ecosystem structure and function by beaver (Castor

- canadensis) in the Adirondack Mountains, New York. *Canadian Journal of Zoology* 69:55-61.
- Smith, R.L., and L.D. Flake. 1983. The effects of grazing on forest regeneration along a prairie river. *Prairie Naturalist* 15:41-44.
- Stelfox, J.B., ed. 1995. Relationship between stand age, stand structure, and biodiversity in aspen mixedwood forests in Alberta. Jointly published by Alberta Environmental Centre, Vegreville, AB and Canadian Forest Service, Edmonton, AB. 308 pp.
- Sun, D. 2003. Wyoming grassbank paying off. *Western Livestock Journal* 82(12):5.
- Taylor, D.M. 1986. Effects of cattle grazing on passerine birds nesting in riparian habitat. *Journal of Range Management* 39:254-258.
- Tueller, P.T., and L.A. Monroe. 1980. Management guidelines for selected deer habitats in Nevada. University of Nevada Agricultural Experiment Station Publication No. R-104. 185 pp.
- U.S. Forest Service. 1993. Changing conditions in southwestern forests and implications on land stewardship. U.S. Forest Service, Southwest Region. 8 pp.
- Vera, F.W.M. 2000. Grazing history and forest ecology. CABI Publishing, New York, NY. 506 pp.
- Vetter, S.D. 2003. BLM proposes grazing changes. *Western Livestock Journal* 82(21):1,10.
- Wall, T.G., R.F. Miller, and T.J. Svejcar. 2001. Juniper encroachment into aspen in the northwest Great Basin. *Journal of Range Management* 54:691-698.

- Wallmo, O.C., and W.L. Regelin. 1981. Rocky mountain and intermountain habitats. Part 1. Food habits and nutrition. Pages 387-38 in Wallmo, O.C., ed. Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, NE. 605 pp.
- Weatherill, R.G., and L.B. Keith. 1969. The effect of livestock grazing on an aspen forest community. Alberta Department of Lands and Forests, Fish and Wildlife Division Technical Bulletin No. 1. 31 pp.
- Weinstein, J. 1979. The condition and trend of aspen along Pacific Creek in Grand Teton National Park. Pages 78-82 in Boyce, M.S., and L.D. Hayden-wing, eds. North American elk: Ecology, behavior and management. University of Wyoming, Laramie, WY. 294 pp.
- West, N.E., K. McDaniel, E.L. Smith, P.T. Tueller, and S. Leonard. 1994. Monitoring and interpreting ecological integrity on arid and semi-arid lands of the western United States. New Mexico Range Improvement Task Force, Las Cruces, NM. Report 37. 15 pp.
- Westworth, D.A., and E.S. Telfer. 1993. Summer and winter bird populations associated with five age-classes of aspen forest in Alberta. Canadian Journal of Forest Research 23:1830-1836.
- White, C.A. 2001. Aspen, elk, and fire in the Canadian Rocky Mountains. Ph.D. Dissertation, University of British Columbia, Vancouver, BC. 205 pp.
- White, C.A., C.E. Kay, and M.C. Feller. 1998a. Aspen forest communities: A key indicator of ecological integrity in the Rocky Mountains. Pages 506-517 in Munro, N.W.P., and J.H.M. Wilison, eds. Linking protected areas with working

landscapes conserving biodiversity. Science and Management of Protected Areas Association. Wolfville, NS.

White, C.A., C.E. Olmsted, and C.E. Kay. 1998b. Aspen, elk, and fire in the Rocky Mountain national parks of North America. *Wildlife Society Bulletin* 26:449-462.

White, C.A., M.C. Feller, and S. Bayley. 2003. Predation risk and the functional response of elk-aspen herbivory. *Forest Ecology and Management* (in press).

Winternitz, B.L. 1980. Birds in aspen. Pages 247-257 in Degraff, R.M., ed. Workshop proceedings on management of western forests and grasslands for nongame birds. U.S. Forest Service General Technical Report INT-86.

Young, J.L. 1973. Breeding bird populations and habitat utilization in aspen stands of upper Logan Canyon. M.S. Thesis, Utah State University, Logan, UT. 38 pp.

Young, J.L. 1977. Density and diversity responses of summer bird populations to the structure of aspen and spruce-fir communities on the Wasatch Plateau, Utah. Ph.D. Dissertation, Utah State University, Logan, UT. 79 pp.