

# Aspen Herbivory



## Elk

**Bailey, J.K., J.A. Schweitzer, B.J. Rehill, D.J. Irschick, T.G. Whitham, and R.L. Lindroth. 2007. Rapid shifts in the chemical composition of aspen forests: an introduced herbivore as an agent of natural selection. *Biological Invasions* 9:715–22.**

**Objective:** To examine whether the variation in aspen chemistry resulted in selective herbivory by elk.

**Methods:** In 2001, we removed the fence protecting aspen saplings from elk browsing. Aspen saplings were protected from elk since their emergence after a crown fire in 1996. These aspen were all 5-6 years old and 10-16.5 ft (3-5 m) in height. Elk browsed aspen primarily in the winter.

**Results:**

1. One year after removal of the enclosure, trees browsed by elk were more likely to die as a result of herbivory than trees that were not browsed.
2. As tremulacin concentrations increased, mortality of aspen related to herbivory by elk declined. Saplings experienced an 80% chance of dying, due to severe herbivory, when tremulacin concentration was 2%, but only a 5% chance of dying when the concentration was 8%.
3. Tremulacin is a phenolic glycoside produced by aspen ramets that is thought to deter livestock and wildlife from browsing aspen. Four years after the removal of the enclosure, 73% of the aspen had been browsed and 61% were dead as a result

**Conclusions:** With the removal of a large enclosure, elk eliminated 60% of the aspen previously protected from herbivory resulting in a dramatic shift in the defensive chemical composition of the aspen Stand.

**S.C. Wooley, S. Walker, J. Vernon, and R.L. Lindroth. 2008. Aspen Decline, Aspen Chemistry, and Elk Herbivory: Are They Linked? *Rangelands* 30:17-21.**

**Location:** Manti-LaSal National Forest above Ephraim, Utah.

**Objective:** To determine the correlation between elk preference for aspen and its defensive chemistry.

**Methods:** 1 kg (2.2 lbs) of aspen browse material (branches with leaves) from five different clones were collected daily. Bundles were tied tightly to the fence inside the pen to prevent the elk from tearing them off of the fence. All aspen bundles were presented at equal heights (approximately 1.6 m [5 feet]) in both the trial and acclimation periods. In each trial, the elk were allowed to choose among the five bundles (one bundle from each aspen clone) placed 2–2.5 m (6.5–8 feet) apart. The trials were repeated on five different days.

**Results:**

1. Consumption of aspen clones by elk differs
2. Phenolic glycosides are negatively correlated with elk herbivory

**Zeigenfuss, L.C., D. Binkley, G.A. Tuskan, W.H. Romme, T. Yin, S. DiFazio, and F.J. Singer. 2008. Aspen ecology in Rocky Mountain National Park: Age distribution, genetics, and the effects of elk herbivory: U.S. Geological Survey Open-File Report 2008-1337. 52 p.**

Lack of recruitment and canopy replacement of aspen stands that grow on the edges of grasslands on the low-elevation elk winter range of Rocky Mountain National Park (RMNP) in Colorado have been a cause of concern for more than 70 years.

**Methods:** We used a combination of traditional dendrochronology and genetic techniques as well as measuring the characteristics of regenerating and non-regenerating stands on elk winter range to determine when and under what conditions and estimated elk densities these stands established and through what mechanisms they may regenerate.

**Results:**

1. From 1975 to 1995 at low elevations on the east side had 80–95 percent fewer aspen stems than would be expected based on the trend from 1855 through 1965.

2. The age structure of aspen indicates that interacting effects of fires, elk population changes, and livestock grazing had about the same effects on aspen from 1855 to 1965.
3. Since aspen numbers have not changed in recent decades, at higher elevations and the west side of the park elk browsing may be more important in reducing aspen numbers than other factors.
4. The genetic variation of aspen populations in RMNP is high.
5. We thought most patches of aspen in the park were composed of a single clone, but in fact just 7% of measured aspen patches consisted of a single clone.
6. A large proportion of polyploid (triploid and tetraploid) genotypes was found on the low elevation, east-side of RMNP (elk winter range).
7. Non-regenerating aspen stands on the winter range had higher levels of browsing, shorter saplings, and lower densities of mid-height (1.5-2.5 m) saplings than regenerating stands.
8. Overwinter elk browsing, however, did not appear to inhibit the leader length of aspen saplings.
9. The winter range aspen stands of RMNP appear to be highly resilient despite very intense herbivory by elk and harsh environmental conditions.

Conclusion: Conservation efforts through fencing protection and decreased elk browsing pressure are already being planned as part of the park's new elk management plan. If these efforts are undertaken, conditions that encourage stem recruitment to the tree canopy will likely result and the continued survival of these aspen stands will be enhanced.

**W.H. Romme, M.G. Turner, G.A. Tuskan, and R.A. Reed. 2005. Establishment, persistence, and growth of aspen (*Populus tremuloides*) seedlings in Yellowstone National Park. *Ecology* 86: 404-418.**

Background: Though uncommon widespread establishment of seedling aspen occurred in Yellowstone following the 1988 fires.

Objective 1: To investigate the patterns and mechanisms of new aspen genet establishment, growth, and survival during their first decade of development.

Results:

1. Aging of 173 aspen stems in 1996 demonstrated that 65% had established within the first three years after the 1988 fires, and that none pre-dated 1988.

2. Genetic analyses revealed that 92% of the plants were genetically distinct individuals, and 8% were ramets.
3. Annual surveys of 22 permanently marked aspen seedling plots revealed that 24% of 417 seedlings tallied in 1996 had died by 2000.
4. Mortality varied greatly among the 22 plots, from <10% to >40%, with greater mortality at lower elevations and where soil organic matter was low.

Objective 2: To evaluate the mechanisms underlying seedling persistence or mortality.

Methods: We constructed exclosures on three sites to protect aspen seedlings from ungulate browsing, and applied four experimental treatments from 1996 to 1998:

1. Clipping current year's growth to simulate browsing,
2. Removing competitors including lodgepole pine saplings and herbaceous plants
3. Clipping current year's growth and competitor removal
4. Control: protection from browsing with no other treatments

Results:

1. Clipping prevented stem elongation, but removing competitors had no effect on height growth of aspen seedlings.
2. Even with protection from browsing, most aspen stems grew slowly (mean increment <10 inches from 1996 to 2000)
3. Many died from causes unrelated to herbivory
4. Some individuals were >2 m tall in 2003 and appeared vigorous.

Conclusions: Aspen that germinated after the 1988 fires may be in the earliest stages of a long-term population process that will likely entail a shift from many genetically distinct individuals (genets) with few ramets, to relatively few genets having numerous ramets. We predict that many of the post-1988 aspen seedlings will die within the next few decades, with little lasting effects. However, some new genets will likely to survive and to establish new aspen clones, with potentially important consequences for demographic and genetic structure of the Yellowstone aspen population.

**D.T. Barnett and T.J. Stohlgren. 2001. Aspen persistence near the National Elk Refuge and Gros Ventre Valley elk feedgrounds of Wyoming, USA. *Landscape Ecology* 16:569-580.**

**Background:** We investigated aspen regeneration in the Gros Ventre River Valley, the National Elk Refuge and a small part of Grand Teton National Park, Wyoming, USA to see if elk browsing was as damaging as previously thought.

**Methods:** We conducted a landscape-scale survey to assess aspen regeneration across gradients of wintering elk concentrations using 68 randomly selected aspen stands in the 420 sq. miles (269,000 acres) study area.

**Results:**

1. 44% percent of the stands sampled supported some newer regeneration that had reached the canopy.
2. There were differences in aspen regeneration across elk winter range classification or distance from feed grounds.
3. However, a multiple linear regression found that the concentration of elk was one of several important predictors of successful aspen regeneration.

**Conclusions:** Our results suggest that stand-replacing regeneration occurs across the landscape at a variety of elk densities despite some trends of reduced regeneration under greater elk concentrations. We propose that high spatial and temporal variation and scattered patches of successful aspen regeneration characterize aspen persistence between periods of episodic regeneration and recruitment.

**Brodie, J., E. Post, F. Watson, and J. Berger. 2012. Climate Change Intensification of Herbivore Impacts on Tree Recruitment. *Proceedings of the Royal Society B: Biological Sciences* 279: 1366–70.**

This paper focuses on aspen and climate change.

**Results:**

1. Declining snowpack increased the impacts of elk on aspen.
2. Thick snowpack reduced elk visitation to sites and aspen shoots in these areas experience lower browsing rates, higher survival and enhanced recruitment.
3. Aspen inside herbivore exclosures had higher levels of recruitment, particularly at sites with thick snowpack.

**Conclusions:** Long-term decreases in snowpack could help explain in part a widespread decline of aspen. Reduced

snowpack across the Rocky Mountains, combined with rising elk populations, may jeopardize recruitment aspen. These results highlight how herbivore behavior changes relative to snowpack and may affect aspen persistence.

## Big Game and Cattle

**S.C. Walker, V.J. Anderson, R.A. Fugal. 2014. Big game and cattle influence on aspen community regeneration following prescribed fire. *Range Ecology and Management***

**Location:** 142 ha prescribed burn conducted in an aspen-conifer stand on the Ferron District of the Manti-LaSal National Forest in 1989.

**Objective:** To measure the effects of cattle and big game grazing on regenerating aspen communities.

**Methods:** Three study sites. Each sites was subdivided into four areas. **Treatments:** big game and cattle exclusion (no use), big game exclusion (cattle), cattle exclusion (big game), and dual use.

**Results:**

1. Aspen and understory regeneration was similar between cattle and controls.
2. Big game Use was slightly more impactful.
3. Dual resulted in low aspen regeneration and an early seral herbaceous community.
4. In 2005, Dual use aspen cover (4%) was lower than the other three treatments: big game (25%), cattle (31%), and controls (34%).

**Conclusions:** Controlled burning to regenerate aspen must be accompanied by a stocking rate reduction for both big game and cattle to allow suckers to develop beyond the browse line.

**R.L. Beschta, J.B. Kauffman, D.S. Dobkin , L.M. Ellsworth. 2014. Long-term livestock grazing alters aspen age structure in the northwestern Great Basin. *Forest Ecology and Management* 329:30–36.**

**Objectives:** To determined the age structure of quaking aspen over the period 1850–2009 in Hart Mountain National Antelope Refuge riparian areas to evaluate potential influences of (a) livestock herbivory and (b) climate on aspen demography.

**Results:**

1. Aspen recruitment declined in the late 1800s with the onset intensive livestock grazing.
2. After enactment of the Taylor Grazing Act (1936), levels of aspen recruitment were still low.
3. Livestock grazing was terminated in 1990. Aspen recruitment increased by more than an order of magnitude compared to levels occurring during the previous half-century of regulated grazing.
4. Climate variables (i.e., Palmer Drought Severity Index, annual precipitation, and annual temperature) appeared to have little influence on long-term patterns of aspen recruitment.

Conclusions: Overall, livestock herbivory was the major factor associated with reduced aspen recruitment. Where long-term declines in aspen are currently underway on grazed lands in the western US, land managers need to carefully consider the potential effects of livestock and alter management to ensure retention of aspen and their ecosystem services. THE AUTHORS NEVER MENTIONED WILDLIFE GRAZING

**Bork, E.W., C.N. Carlyle, J.F. Cahill, R.E. Haddow, and R.J. Hudson. 2013. Disentangling herbivore impacts on populus tremuloides: a comparison of native ungulates and cattle in Canada's aspen parkland. *Oecologia* 173:895-904.**

Objective: To determine if native herbivores compared to beef cattle are more likely to prevent aspen encroachment into grasslands of the Northern Great Plains.

Methods: The study compared the impacts of native ungulates and cattle on aspen saplings. Herbivory treatments were 1) cattle, 2) a different sequence of herbivores: deer then elk then bison, 3) a sequence of herbivores bison then elk then deer, and 4) all three species at the same time. Herbivory treatments were replicated in three pastures and compared to a non-grazed aspen stand. Aspen stems were assessed for mortality and incremental damage (herbivory, leader breakage, stem abrasion and trampling). Herbivores grazed the paddocks for 6 weeks. Aspen forest covered 7.2-8.9% of the paddocks, grassland (51.4-59.2 %), shrubland (30.4-32.6 %) and riparian meadows (1.5-8.8 %) covered the remaining area.

Results:

1. Mortality was greater with any herbivore compared to unbrowsed plots, but was similar between treatments.
2. Cattle browsing aspen was negligible.

3. Impacts of cattle and bison on aspen were associated primarily with physical damage to saplings other than defoliation.
4. Elk browsed aspen to a greater extent than other ungulates and use on aspen tended to increase as the season progressed.

Conclusion: Overall, these results indicate that native ungulates, specifically elk and bison, have more negative impacts on aspen saplings.

**Kay, C E. 2012. The impact of native ungulates and livestock on western aspen communities. Restoring the West Conference 2006: Aspen Restoration, November, 1-1.**

Background: Repeated browsing by mule deer, elk, cattle, or domestic sheep often prevents aspen from successfully regenerating (greater than 6 ft tall) on intermountain ranges.

Results:

1. Bark damage by elk can also hasten the decline of existing aspen ramets.
2. If ungulate herbivory is excessive, fire will not regenerate aspen. Instead, fire plus excessive herbivory only hastens the decline of aspen.
3. Beaver-felled aspen will not regenerate if emerging suckers are repeatedly browsed by wildlife or livestock.
4. Deer, elk and sheep tend to remove palatable shrubs and forbs, while cattle eliminate native grasses.
5. Aspen stands heavily used by wildlife and livestock are usually dominated by unpalatable forbs and non-native grasses, such as timothy or Kentucky bluegrass.
6. Late 1800 photographs indicate that, historically, aspen was not browsed. First-person journals and archaeological data indicate that before European settlement, hunting by native people kept ungulate populations at very low levels.

Conclusion: The heavily browsed aspen communities seen on many western ranges today are entirely outside the range of historical variability.

**Kay, C E, and D L Bartos. 2000. Ungulate herbivory on Utah aspen: assessment of long-term exclosures. *JRM* 53:145-53.**

Objective: to determine role of ungulate browsing in the decline of aspen in the Intermountain West.

Methods: Aspen exclosures on the Dixie and Fishlake National Forests in south-central Utah were measured during late summer of 1995 and 1996 to determine aspen stem dynamics, successional status, and understory species composition. Five of the exclosures were a 3-part design with a total-exclusion portion, a livestock-exclusion portion, and a combined-use portion.

#### Results:

1. Aspen protected from all ungulates regenerated and developed multi-aged stems without fire or other disturbance.
2. Aspen browsed by wildlife, primarily mule deer, either failed to regenerate or regenerated at stem densities lower (2,498 stems/ha) than total-exclusion plots (4,474 stems/ha).
3. On wildlife-livestock plots, most aspen failed to regenerate or did so at low stem densities (1,012 stems/ha).
4. Aspen successfully regenerated only when deer numbers were low.
5. Ungulate herbivory affected on understory species composition.
6. Utilization by deer reduced shrubs and tall palatable forbs and favored native grasses.
7. The addition of livestock grazing tended to reduce native grasses while promoting introduced species and bare soil.

Conclusions: Communities dominated by old-age or single-age trees appear to be a product of ungulate browsing, not a biological attribute of aspen. There was no evidence that climatic variation affected aspen regeneration.

## Cattle

**R.D. Fitzgerald, R.J. Hudson, and A.W. Bailey. 1986. Grazing preferences of cattle in regenerating aspen forest. *Journal of Range Management* 39:13-18.**

Objective 1: To determine the relative preferences of cattle in regenerating aspen stands following burning.

Objective 2: To develop strategies to control aspen regrowth using grazing with cattle.

#### Results:

1. Cattle tended to graze forest rather than grassland.
2. This tendency increased as grasses matured near the end of the growing season.

3. Within the forest, cattle preferred grasses and forbs when present.
4. Of the shrubs, generally wild rose and wild raspberry were preferred over aspen.
5. However, aspen was preferred over western snowberry.
6. Cattle grazed aspen more readily late rather than early in the season.
7. Snowberry, which was of consistently of low acceptability, was more acceptable late rather than early in the season.
8. Cattle readily consumed wild raspberry in both years and both seasons.
9. Wild rose was eaten early in the season in both years. It was less preferred late in the season when it had relatively more woody growth.

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## Beaver

**J.M. Basey, S.H. Jenkins and P.E. Busher. 1988. Optimal central-place foraging by beavers: Tree-size selection in relation to defensive chemicals of quaking aspen. *Oecologia* 76:278-282.**

**Results:**

1. At a newly occupied pond (SITE 1), beavers preferred aspen smaller than 7.5 cm in diameter and selected against larger aspen.

2. After a year, 10% of the aspen at SITE 1 had been cut and 14% of the living aspen exhibited the juvenile growth form.
3. Aspen bark contained low concentrations of a phenolic compound. There was no relationship between the concentrations of the phenolic compound and tree diameter.
4. At a pond, which was intermittently occupied by beavers for over 28 years (SITE 2), beavers selected against aspen smaller than 4.5 cm in diameter, and preferred aspen larger than 19.5 cm in diameter.
5. At this site, 51% of the aspen were cut and 49% of the living aspen were juveniles.
6. Concentrations of the phenolic compound were higher in bark at SITE 2 than SITE 1.
7. Concentrations of the phenolic compound were negatively correlated with tree diameter at SITE 2.
8. Results of this study show damage to aspen increases as concentrations of secondary metabolites increases in bark through time.

## Pocket Gophers

**Coggins, S.T. and M.R. Conover. 2005. Effect of Pocket Gophers on Aspen Regeneration. *Journal of Wildlife Management* 69: 752-59.**

**Results:** No effect of pocket gophers on aspen regeneration.

## Effect of Herbivory on Aspen Regeneration after Fire

**Wan, H.Y., A.C. Olson, K.D. Muncey and S.B. St. Clair. 2014. Legacy effects of fire size and severity on forest regeneration, recruitment, and wildlife activity in aspen forests *Forest Ecology and Management* 329:59-68.**

**Background:** Human activities are increasing the size and severity of wildfires, creating a need for research that links changes in fire regimes with community level responses.

**Objective:** To understand how variability in fire regimes influences forest regeneration and recruitment patterns and wildlife activity at large temporal and spatial scales.

**Location:** Across 25 fires in five National Forests (Uinta-Wasatch-Cache NF, Ashley NF, Fishlake NF, Dixie NF, and Manti-La Sal NF) in the state of Utah.

**Methods:** We measured aspen regeneration and recruitment levels, and wildlife and livestock fecal counts along belt transects of fires of different size and severity. Changes in forest cover were measured by comparing satellite images pre-fire and post-fire. Fires occurred from 1992 to 2002 and were at least 10 years old when this study was conducted.

**Results:**

1. Fire size and severity were positively related to aspen regeneration (density of saplings) and recruitment (saplings >2 min height).
2. There was a fire size and severity interaction effect on aspen regeneration
3. The positive influence of fire size increased with greater fire severity.
4. Changes in the extent of aspen cover were not correlated with fire size.
5. Deer and cattle became more dispersed with increasing fire size and severity, but elk activity showed did not.
6. Deer preferred low severity burn patches in smaller fires, but appeared to avoid low severity patches as fires became larger.

**Conclusions:** Fire size and severity are important factors that can interact to affect forest development and the distribution and abundance of large herbivores. Effective management of forest systems in response to different fire regimes will require an understanding of the legacy effects of fire size and severity at the landscape scale.

**Wan, H.Y., A.C. Rhodes, and S.B. St. Clair. 2014. Fire severity alters plant regeneration patterns and defense against herbivores in mixed aspen forests. *Oikos* 123:1479-1488.**

**Background:** Fire and herbivory are disturbances that strongly influence aspen plant community development, but it is unclear how herbivory changes with burn severity.

**Objective:** To examined herbivory patterns, herbage growth responses and defense chemistry (phenolic glycoside, condensed tannins) of regenerating aspen that experienced variable burn severity in the 2010 Twitchell Canyon Fire in Utah.

**Results:**

1. Damage to aspen by large herbivores was about 60% lower in plots where burn severity was moderate to high rather than low or unburned plots.

2. Density of regenerating aspen trees was 2.3 and 3.1 times greater where burn severity was moderate or high rather than low or in unburned plots.
3. High burn severity stimulated photosynthesis and increased vertical growth and biomass produced.
4. Defense chemistry responded over time depending on burn severity.

- From June to August, phenolic glycoside (PG) concentrations did not change in unburned plots or under low severity fire conditions
- In moderate and high severity burn plots PG increased 79% and 139% from June to August.
- By the end of summer, condensed tannins increased six fold in high severity burn plots.
- In the low severity plots, tannins increased 50% or less in the same time period.

1. Deer activity decreased in areas where fire severity was the greatest
2. Deer activity increased where browse damage was the greatest.
3. Elk and cattle activity showed no relationship with browse activity.

**Conclusions:** The increase in available sunlight to regenerating aspen trees in high severity burn areas may increase tolerance and resistance of aspen to herbivory by increasing both the growth rate and concentrations of defensive compounds in aspen. Higher fire severity may improve aspen regeneration and recruitment by increasing its resilience to herbivory.

**Wilde, T.W. 2014. The effect of large fire on aspen recruitment. *Journal of the NACAA* 7(1): <http://www.nacaa.com/journal/index.php?jid=340>**

**Background:** In 2000, the forest service completed a 1,329-acre controlled burn on Monroe Mountain, Utah to aid aspen regeneration on the mountain. After the fire, the aspen clone suffered complete failure due to over-grazing by livestock and wildlife.

**Objective:** To explored the effect of large-scale disturbance (fire) on aspen recruitment.

**Methods:** The Pole Creek Fire was compare with the Oldroyd fire. Lightening caused the Pole Creek fire in 1996. It burned 7,113 acres approximately twenty miles west of the Oldroyd Fire. The amount of aspen in the area before and after the Pole Creek Fire was determined using a combination of on the ground assessments and ArcGIS software.

## Results:

1. Aspen recruitment after the Pole Creek fire totaled 2,164 acres.
2. Aspen or aspen/conifer areas which burned but had no aspen recruitment post-fire was estimated at 887 acres.
3. Thus, the post-fire aspen acres were 3,051 acres.
4. The ratio of post-fire aspen compared to pre-fire aspen was 71%.

Conclusions: Thousands of acres of seral aspen are threatened by conifer encroachment, but small fire treatments are susceptible to clone failure due to grazing. Data from this study suggest that larger scale fires would allow land managers to address aspen loss due to conifer encroachment and reduce the impact of grazing on regenerating aspen.

**Endress, B.A., M.J. Wisdom, Martin Vavra, C.G. Parks, B.L. Dick, B.J. Naylor, and J.M. Boyd. 2012. Effects of ungulate herbivory on aspen, cottonwood, and willow development under forest fuels treatment regimes. *Forest Ecology and Management* 276:33-40**

Introduction: Intensive grazing by native and domestic ungulates may reduce or eliminate aspen, cottonwood, and willow. Herbivory may favor greater establishment of conifers that may result in stand-replacing fires. High fuel loads often require fuels reductions to mitigate fire risk, which in turn may facilitate additional recruitment of deciduous woody species but also additional herbivory pressure. Potential interactions of ungulate herbivory with episodic disturbances of logging, fire, and other land uses are not well documented, but may interact to affect forest dynamics.

Objective: To evaluate the effects of ungulate herbivory and thinning in grand fir and Douglas fir forests.

Methods: We use mechanical thinning and prescribed fire and evaluated the responses of aspen, cottonwood, and willow species to these treatments (N = 3) versus areas of no treatment (N = 3), and to exclusion from ungulate herbivory versus areas subjected to extant herbivory by free-ranging cattle, elk, and mule deer.

## Results:

1. Densities of deciduous species were >4 times higher in response to thinning (84.4 individuals/ha) compared to areas of no treatment (19.7 individuals/ha).

2. When ungulates could not graze sites that were thinned, the density of cottonwood was >5 times higher (122.5 individuals/ha) than fuels treated sites that were grazed (24.3 individuals/ha).
3. Densities of aspen and willow were >3 times higher (211.6 individuals/ha) on fuels treated sites excluded from herbivory versus fuels treated sites subjected to herbivory (66.1 stems/ha).
4. Deciduous species subjected to grazing also were lower in height, canopy surface area, and canopy volume than the same species inside the ungulate exclosures.

Conclusion: Recruitment and long-term survival of aspen, cottonwood, and willow species in coniferous forests of interior western North America require a combination of episodic disturbances such as silviculture and fire to facilitate deciduous plant recruitment, followed by reductions in grazing pressure by domestic and wild ungulates during the time intervals between episodic disturbances to facilitate plant establishment, growth and survival.

**Smith, E.A. D. O'Loughlin, J.R. Buck, S.B. St. Clair. 2011. The influences of conifer succession, physiographic conditions and herbivory on quaking aspen regeneration after fire. *Forest Ecology and Management* 262: 325-330.**

Over the last century, fire suppression has increased expansion of conifers in aspen-conifer forests and may be a driving force behind aspen.

Objectives: To examine how increasing conifer dominance affects aspen regeneration after fire. Physical geographic features and herbivory on aspen regeneration vigor were also examined.

Location: Sanford fire complex located in the Dixie National Forest in southern Utah. More than 31,000 hectares burned in the summer of 2002.

Methods: In 2009, we measured aspen regeneration density and former stand composition and density and correlated them with soil characteristics, slope, aspect and presence or absence of herbivory.

## Results:

1. Aspen regeneration densities ranged from <500 to 228,000 stems/hectare with an average of 37,000 stems/hectare.
2. Post-fire aspen regeneration density was most strongly correlated with percent conifer abundance

( $R^2 = -0.55$ ) and overstory aspen density ( $R^2 = +0.50$ ).

3. Average aspen suckering densities ranged from approximately 60,000 stems/hectare in former stands of relatively pure aspen (>90% aspen) to less than 5000 stems/hectare in stands where conifer abundance was greater than 90%.
4. Soil C, N, and P showed positive correlations ( $R^2 = 0.07$  to  $0.17$ ) with aspen regeneration vigor,
5. Soil texture had a relatively weak influence on sucker regeneration.
6. Aspen regeneration densities were 15% lower on north facing slopes compared to east, west and south facing slopes.
7. Slope steepness was not correlated with regeneration vigor.
8. Regeneration density was 8% lower at sites with evidence of herbivory versus sites where herbivory was absent.

**Conclusions:** As general guidelines we provide the following recommendation for forest managers where maintenance of aspen is desired: promote fire in landscapes when the percentage of overstory conifer stems is greater than 80% or overstory aspen density is less than 200 overstory stems/hectare. Furthermore, aspen regeneration in this study was successful because the large disturbance size and the strong suckering response resulted in high aspen suckering densities over a large area that effectively saturated the browsing capacity of the ungulate herbivore community.

**Durham, D.A. 2008. Aspen response to prescribed fire in southwest Montana. M.S. Thesis. Montana State University, Bozeman, Montana.**

Edited Excerpt: Multiple comparison analysis indicated mean sucker height was different between no grazing and grazing by big game ( $P = 0.012$ ) and by big game and cattle ( $P = 0.003$ ) plots. However, there was no difference in mean sucker height between BG and BGC treatment plots.

Table 5. Comparison of mean sucker height among herbivore treatments in burned portions of the Whitetail Basin. Differences are indicated by letters at  $P < 0.05$ . Treatment Sample size Range (cm) Mean (cm) SD P-value(plots)

No Use	5	99-124	108a	10
Big Game	5	76-103	88b	11
BG/Cattle	5	72-97	83b	10

Our results indicate big game browsing had a negative affect on mean sucker height. This agreed with studies

of Walker 1993 and Kilpatrick 2003. However, our findings differ from Renkin and Despain (1996) who found no difference in sucker height inside and outside of exclosures in Yellowstone National Park. Our results also contradict White et al. (1998) who state elk impacts on aspen will not be evident when elk density is less than 1 elk/km<sup>2</sup>. Aspen stand size may be more important than the density of elk in a given location. In fact when aspen is sparse, elk density may not matter at all as a few elk could potentially seek out all aspen and negatively impact regeneration.

A combination of big game and cattle did not have a cumulative affect as found in other studies (Walker 1993, Kilpatrick et al. 2003). Thus, cattle had a minimal impact on sucker height in this area. However, cattle were present on only two of our BGC plots in 2006 and 2007, and all five plots in 2008. Our observations indicated cattle browsed very few suckers in Hay Canyon until most of the grass biomass was removed from the riparian areas. The cattle were then removed before they ate very many aspen stems. Cattle browsed even fewer suckers during the spring at the Little Whitetail allotment. Low sucker use seemed to correspond with the presence of abundant palatable grass, and removal of the cattle while sufficient residual forage remained. These observations agreed with DeByle (1985) that, if cattle grazing is light to moderate, use of aspen will be as well. This suggests cattle can be effectively managed to minimize impacts on aspen regeneration.

## Fallen Trees Protect Regenerating Aspen

**Kota, A.M. and D. L. Bartos. 2010. Evaluation of Techniques to Protect Aspen Suckers From Ungulate Browsing in the Black Hills. Western Journal of Applied Forestry 25: 161-68.**

**Objective:** To compared the utility of livestock fences, complete wildlife exclosures, barriers created from slash debris, and tree hinging in the Black Hills of South Dakota.

**Results:**

1. All barriers reduced browsing of aspen suckers compared with pre-treatment (78%) and post-treatment (79%) controls.
2. Slash treatments and livestock fences decreased ungulate browsing by 19%
3. Hinge treatments decreased aspen browsing by 39%

4. Wildlife fences eliminated nearly all sucker browsing.
5. The average length removed per terminal stem for aspen suckers decreased from 20.8 to 14.4 cm for all treatments.
6. After a year, the number of suckers above 100 cm tall in both hinge and slash treatments were greater than both the fence treatments and control.
7. Autumn and winter browsing was primarily by wild ungulates.
8. Slash barriers can replace livestock fences where cattle browse aspen suckers.
9. Hinge barriers are more useful than slash barriers and livestock fences in areas where wild ungulates are the primary browsers.

2. Treatments supported adequate density of saplings to meet recommendations for ruffed grouse.
3. Shrub cover also was greater in treatments with slash and fencing.
4. Unfenced trts w/slash less than 8 cm diameter, did not differ from fenced treatments
5. Unfenced trts w/slash didn't support enough aspen density to meet ruffed grouse habitat requirements.

Conclusion: The density of aspen saplings will vary in response to these treatments in other locations. We recommend retaining all slash after clear cutting aspen as an alternative to fencing to protect aspen suckers.

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**W.J. Ripple and E.J. Larsen. 2001. The Role of Postfire Coarse Woody Debris in Aspen Regeneration. West. J. Appl. For. 16:61-64.**

Objective: To examine the role of coarse woody debris as a mechanism for assisting aspen regeneration.

Location: We located 1988 burned sites on YNP's northern range and searched for "jackstraw piles," where fallen conifers protected aspen from ungulate browsing.

Results: Aspen suckers protected by fallen conifer barriers were on average over two times the height of adjacent unprotected suckers.

Conclusion: These results show fallen conifers can play in aspen regeneration.

**Rumble, M.A., T. Pella, J.C. Sharps, A.V. Carter, and J.B. Parrish. 1996. Effects of Logging Slash on Aspen Regeneration in Grazed Clearcuts. The Prairie Naturalist 28:199-209.**

Objective: To evaluate the effects of leaving slash after a clearcut and fencing on regeneration of aspen 19 years after years.

Methods:

1. A quaking aspen stand was clearcut.
2. Fencing and slash retention treatments were designed to exclude or impede livestock-use.

Results after 19 years:

1. Leaving all slash was as effective as fencing for maintaining aspen regeneration.