SIMULATED BROWSING IMPACTS ON ASPEN SUCKER'S SURVIVAL
AND GROWTH

By
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of the requirements for the degree
of
DOCTOR OF PHILOSOPHY
In
Range Science

Approved:

Laurens Smith
Interim Dean of Graduate Studies

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INTRODUCTION
Western forests dominated by aspen (*Populus tremuloides* Michx.) are highly regarded by most resource managers for their ability to provide a variety of benefits (Bartos and Mueggler 1982, Mueggler 1988). They noted aspen to be beneficial for production of livestock forage, wildlife habitat, and scenic beauty, and they are a potentially valuable source of wood products. However, in the West, communities are concerned about the dwindling acreage of aspen. The decline of aspen has been partly attributed to excessive ungulate browsing (Smith et al. 1972, Collins and Urness 1983, Bartos and Campbell 1998). Long-term grazing exclosures have also revealed that browsing by native and domestic ungulates hindered aspen regeneration throughout south-central Utah, including changes in understory species composition (e.g. Kay and Bartos 2000). However, though ungulate browsing is an established cause of poor success in aspen regeneration, beyond that fact, very little is known about the particulars of the response, especially how it is affected by time and intensity of browsing.
LITERATURE REVIEW

Introduction

There are not many studies that have been done on simulated browsing on aspen. However, several clipping studies have been conducted on other woody species browsed by big game and range livestock. Though little is known about aspen, there might be some general principles that can be inferred from similar studies done on other woody species.

Simulated browsing studies on other woody species

In a 4-year clipping study on the Kaibab National Forests, Julander (1937) observed that cliffrose (Cowania stasburiana) clipped so that more than 80 percent of its current year's growth increment was removed will deteriorate, while removal of 70 to 75 percent is the maximum amount which will permit recuperation and perpetuation of cliffrose. He also observed that removal up to 65 percent is beneficial in stimulating growth of cliffrose.

Cook and Stoddart (1960) conducted a 3-year study on desert sagebrush types in central Utah. The study was initiated to determine how sagebrush (Artemisia tridentata) responded to two different types of herbage removal. One treatment involved removing one-half of the current growth of each twig over entire plant and the other was removing all of the current year's growth from only one-half of the plant. They observed that clipping all of the current year's growth from one side of the plant during late winter or early spring caused death of that one-half of the plant after 3 years of treatment. On
clipping one-half of all current year’s growth over the entire plant, vigor of the plant was reduced substantially, but only small isolated twigs or branches were killed. They also concluded that there is little or no translocation of manufactured food from one side of the plant to the other. While these results provide important perspective on the response of woody plants to browsing, the direct implication to the aspen issue is questionable, given the clonal, inter-connected nature of aspen trees.

A 4-year study on the Fremont, Malheur, and Whitman National Forests in Oregon, and the Snoqualmie National Forest in Washington (Garrison 1963) investigated the effects of clipping current twig growth at 25% (lightly clipped), 50% (moderately clipped), 75% (heavily clipped) and 100% (completely clipped) on 5 range shrubs. He suggested levels of use for sustained shrub production on winter ranges in Oregon and Washington: for antelope bitterbrush (Purshia tridentata) on best sites, 60 to 65 percent, and 50 percent on poorer bitterbrush sites; for snowbrush ceanothus (Ceanothus velutinus), 35 to 40 percent; for rubber rabbitbrush (Chrysothamnus nauseosus), 50 percent; for creambush rockspirea (Holodiscus discolor), 50 to 60 percent; and for curlleaf mountainmahogany (Cercocarpus ledifolius) plants completely within reach of grazing animals, 50 to 60 percent. However, he cautioned that the information in this study should be applied only to fall and winter ranges.

A 12-year clipping study was conducted in southwestern Colorado on long-term effects of yearly removal of specific amounts of current-annual-growth (CAG) stems and older material from 5 important browse species: antelope bitterbrush, big sagebrush, oakbrush
(Quercus gambelli), mountain mahogany (Cercocarpus montanus) and serviceberry (Amelanchier alnifolia) (Shepherd 1971). Treatments included annual clipping of 20, 40, 60, and 80 percent of the CAG stems for 12 years and 100 percent for 10 years. He concluded that for serviceberry, annual use of up to 60 percent of the CAG stems, 1 centimeter or more in length, would be beneficial, but that sustained use of 80 percent or more would be harmful and eventually kill the plants. For oakbrush, a 60-percent utilization of CAG on summer and fall ranges was found to be optimum use, while for mountain mahogany browsing intensity of approximately 70 percent proved optimum. He observed that summer and fall use of bitterbrush CAG stems in amounts of 20 to 40 percent promoted plant health and vigor. He also noted that 50 percent use might be acceptable, but a sustained use of 80 percent or more would eventually damage or kill many plants. Though the study demonstrated that big sagebrush maintained high browse production under clippings of 20 to 80 percent, greater proportion of dead branches and plants were noted. Therefore, he concluded that summer and fall use in excess of 50 percent could not be tolerated for an indefinite period.

Willard and McKell (1978) conducted a 5-year study in the Wasatch Mountains of Utah within the Cache National Forest, a typical summer range for cattle, to investigate the effects of simulated browsing on little rabbitbrush (Chrysothamnus viscidiflorus) and snowberry (Symphoricarpus vaccinioides) shrubs at light (30), moderate (60) and heavy (90%) intensities of twig and leaf removal during early (1 June), mid- (15 July), and late season (1 September) use. They observed that thirty percent herbage removal produced an increase in herbage production while more intense defoliation usually caused a
decrease on both species. Sprout vigor was reduced on little rabbitbrush shrubs but not on snowberry.

A 2-year study was conducted southwest of Grand Rapids, Minnesota, to study the effects of overstory and understory competition and simulated white-tailed deer (Odocoileus virginianus Zimmermann) herbivory on growth and survival of white pine (Pinus strobus L.) seedlings (Saunders and Puettmann 1999). Treatments involved 3 intensities of clipping (control, 0% previous year’s growth removed; lightly clipped, terminal and 50% previous year’s growth removed, and heavily clipped: 100% of previous year’s growth removed) and 3 frequencies (never clipped, clipped once, clipped 2 years in a row). They observed that decreasing overstory canopy closure and brush competition generally increased growth of seedlings under all clipping regimes, with heavy clipped seedlings showing least benefit of reduced competition. On the other hand, they also observed that seedling mortality was higher without brush control and after clipping. Since both competition levels and increased herbivory reduced seedling vigor, they concluded that understory brush control and deer protection go hand-in-hand to regenerate white pine.

Puettmann and Saunders (2001) conducted a 2-year study southeast of Grand Rapids, Minnesota, to study, patterns of compensatory growth of eastern white pine (Pinus strobus L.) seedlings as influenced by simulated herbivory intensity and competitive environments. Treatments included, an unclipped control or the removal of the terminal and approximately 25%, 50%, 75% or 100% of last year’s shoots. Seedlings were
growing with different understory competition levels (created through monthly weeding vs. no brush control) under a range of overstory canopy closures. It was noted that after one growing season, seedlings did not fully compensate for lost biomass, regardless of competitive environments of the seedlings. They also observed that, though relative height growth was stimulated by light intensity (20-40% of last-year shoots removed), relative diameter growth, total biomass, and biomass growth of seedlings declined sharply with increasing clipping intensity. On the other hand, all growth parameters declined with increasing inter-specific competition. It was observed that seedlings in highly competitive environments showed smaller growth loss due to clipping than those in competition-free environments. They attributed this to the fact that, seedlings experiencing high inter-specific competition devoted more energy to maintaining apical dominance and a balanced shoot-root ratio. They concluded that compensatory growth follows a complex pattern that will vary with the parameters measured, competitive conditions, and clipping intensities. They also noted that overcompensation maybe an adaptation to competition ability, rather than a response to herbivory itself.

Simulated browsing studies on aspen

Grazing can be most detrimental at the early and late stages of the growing season depending on the level of use (Cook 1971). During the early stages of growth, plants invest much of their root energy resources to carry out physiological processes required by the plant. On the other hand, at this stage the plant cannot satisfy all its metabolic demands through photosynthesis. During the late growing season, the plant requires adequate energy before dormancy period starts. This energy help keep the buds alive to
resume growth when conditions are ideal in the following year. Timing and level of browsing is important for the health of plants to ensure perpetuation. However, most of the studies on herbivory impacts have been on grasses rather than on woody plants. Julander (1937) carried out a clipping study over a 4-year period in the Kaibab National Forest and found out that aspen reproduction will deteriorate if clipped 75 percent or more. He observed that clipping aspen at 65 to 70 percent removal levels will permit fair improvement, greater improvement would occur under light clipping. Aspen was found to be a key forage species for summer range on the Kaibab National Forest. Bailey et al. (1990) stated that defoliating aspen in early fall apparently stimulates (a) shoot primordial to grow too late in the season to permit development of winter hardiness, and (b) prevents shoots which had emerged earlier in the growing season from going into dormancy, leaving them susceptible to winter kill. Dockrill et al. (2004) working on the effects of summer cattle grazing on aspen stem injury, mortality and growth in Alberta, Canada observed that continuous June-July grazing was the most detrimental time for herbivory to occur in impeding aspen regeneration. However, it should be noted that use of aspen is also influenced by abundance of associated forage species.
OBJECTIVES

The objectives of this study are:

1. To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen re-growth.
2. To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen survival.
3. To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen new sucker stimulation.
4. To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen susceptibility to diseases.
HYPOTHESES

In light of the reviewed research on herbivory of aspen and several other woody species, I hypothesize that intensity and season of browsing interact to affect or influence aspen survivorship and re-growth.

The expected responses are as shown in the following Figures 1-6. Assumptions are based primarily on Julander's (1937) study, that browsing beyond the 75% intensity results in aspen deterioration and the Dockrill et al. (2004) study.
Figure 1. Expected responses of individual aspen suckers and/or survival at different intensities of simulated browsing.

Figure 2. Effects of season of simulated browsing on aspen survivorship and/or re-growth.
Figure 3. The interactive effects of season and 0% simulated browsing intensity on aspen sucker survivorship/re-growth.

Figure 4. The interactive effects of season and 25% simulated browsing intensity on aspen sucker survivorship/re-growth.
Figure 5. The interactive effects of season and 50% simulated browsing intensity on aspen sucker survivorship/re-growth.

Figure 6. The interactive effects of season and 75% simulated browsing intensity on aspen sucker survivorship/re-growth.
MATERIALS AND METHODS

Description of the study area

The study area is located on privately owned land at an elevation of 2800 m, approximately 27 km southeast of Cedar City, Utah. Mean annual precipitation ranges between 745-770 mm and mainly comes as winter snowfalls and as much as one-third from summer monsoons (Ohms 2003). The soils are described as Argic Pachic Cryoborolls, with fine montmorillonitic fain clay loam, with slopes of 0-28% (Bowens and Bagley 1986).

The vegetation consist of interspersed mountain grasslands and woodlands of quaking aspen, with patches of Gambel oak (Quercus gambelii Nutt.) (Ohms 2003). The dominant grasses are Letterman needlegrass (Stipa lettermani Vasey), Kentucky bluegrass (Poa pratensis L.), with lesser amounts of mountain brome (Bromus carinatus Hook & Arn), and slender wheatgrass (Agropyron trachycaulum) (Bowens and Bagley 1986). Some areas have rather nice stands of the shrub, snowberry (Synphoricarpos spp). Forbs are also noted to be inconspicuous and somewhat rare in relation to grasses. Common forbs on the area include western yarrow (Achillea millefolium), thickstem aster (Aster integrifolius), lambstowne senecio (Senecio integerrimus), dandelion (Taraxacum officinale Webber ex Wiggers), knotweed (Polygonum douglasii) and the undesirable tarweed (Madia glomearata). These are herbaceous plants common to open areas.

However, under aspen stands, one can expect, varying amounts of forbs and graminoids. Forbs include Thalictrum fendleri, Osmorhiza chilensis, coneflower (Rudbeckia occidentalis Nutt), Hackelia floribunda, while graminoids, include Elymus glaucus,
Kentucky bluegrass (*Poa pratensis* L.), mountain brome (*Bromus carinatus* Hook & Arn), and others. The area has a long history of heavy continuous sheep grazing and it is assumed that the difference between the forb- and grass-dominated areas is the result of livestock grazing (Bowns and Bagley 1986).

**Site selection and preparation**

During early spring of 2005, four aspen clones of the same community type (Mueggler 1988) will be selected in Pasture 10 of the Thorley’s side of the ranch (Fig. 7). The clones will be big enough to accommodate all the treatments for the different seasons. On the other hand it will be ensured that experimental plots are placed on a fairly uniform area in terms of aspect, soils, and topography. Pasture 10 was selected because of easy accessibility with a road leading to the area. Most importantly, the area has numerous aspen stands scattered around.

Portions of the selected clones will be clear-cut in early June, ensuring minimal disturbance to the soil so as not to stimulate suckering from root injury. Suckers should then emerge naturally due to elimination of apical dominance (Schier 1976). Growing points suppress sprouting of new suckers by continually producing auxins that are transported to the roots. However, suckers will be expected to have developed by late June/early July.

**Experimental design**

The experimental design for both the objectives is a randomized block design with repeated measurements. Main effects include season (3 times) and browsing intensity
Figure 7. Showing the pasture layout for the Webster and Thorley ranch in Cedar City. This study will be conducted in pasture 10, as labeled in the figure.
The experimental design for all objectives is a randomized block design and will be used for all objectives unless otherwise stated. Analysis of variance (ANOVA) will be employed to test for significant difference in aspen variables measured between the treatments, within and across seasons, for all objectives testing at a 5% level of probability (Dowdy and Wearden 1983), unless otherwise stated.

The four levels of simulated browsing will be imposed on the experimental plots at 0, 25, 50 and 75% respectively. Twenty-five percent level, for example, will be determined by measuring the height of current year’s growth present at the particular season and then 25% of that amount will be clipped off, using hand clippers. Clippers will be dipped in alcohol each time to minimize disease infection between plots. The same procedure will be done for the other three (3) levels of browsing intensity. The control plot will receive 0% clipping. Each treatment will be replicated four times. Treatments will be allocated randomly to the experimental units.

Treatments will be carried out in early summer (ES), mid-summer (MS) and late summer (LS). Specifically, the first browsing simulation for the 4 intensities will be mid-July (ES), and the second treatment will be mid-august (MS). The third treatment will be made in mid-September (LS).

**Experimental layout**

Three areas each measuring 24m x 24m will be fenced off within a clone by a game proof fence to exclude cattle, deer and elk (Fig. 8). These areas will be randomly chosen within the clear-cut parts of the clone. Caution will be taken, however, to ensure that the areas
Figure 8. Experimental plot layout for each of the 4 replications. Each of these 3 blocks represent a different season.
Figure 9. One experimental plot showing treatment allocation for one experimental unit.
are separated in space by a minimum distance of 10 meters. Within each of these 3 areas, 4 permanent 10m x 10m plots will be established with 2-m buffer zones on both sizes of the plot (see Fig. 9).

**Objective No. 1.** To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen re-growth.

**Data collection**

The response variable is the amount of re-growth realized after treatment imposition. Two, permanent 1 m x 6 m belt transect will be established in each plot on which measurements will be taken. Two metal rods will be driven into the ground on both ends and at the center of each transect for easier identification and ensuring that measurements are made at the same place each time sampling is done. Aspen re-growth will be measured at the 1-, 3- and 5-m positions of each transect using a 1m x 1m quadrant. Aspen re-growth will be determined by measuring the amount of growth from the initial cut point. Average shoot re-growth will then be computed at each quadrat location. Regrowth on shoots will be measured at the end of LS for both levels of intensity. This is the time when temperatures begin to drop, and minimal plant growth typically occurs during this time. Treatments will be imposed every year for 2 years and data collected for 2 consecutive years.

**Objective No. 2.** To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen survival.
Data collection

The response variable is plant density i.e. the number of dead and/or live plants per unit area. This will be used as a measure for plant survival, using the before and after browsing density of plants. Data will be collected on the same plots receiving the 4 treatments as explained for objective 1. The data will be collected before and after the plots have been treated.

Sucker density will be measured by the use of a quadrat as described by Bonham (1989). A quadrat measuring 1 m x 1 m will be used. The quadrat will be randomly located at five different places in each of the plots. Since at this time, the scope of the variation is not known, 5 samples will be taken initially and then sample number will be adjusted as required, once an estimate of variability is known. Individual stems will be counted in each of the quadrats. The number of stems will then be expressed as number of stem suckers per m$^2$ for each quadrat. The change in number of suckers per unit area between sampling dates indicates aspen survival. Measurements will be taken before treatment application for each season, and after treatment application at the end of the LS period for 2 years.

Objective No. 3. To determine the effects of browsing at 4 simulated intensities and 3 seasons on new aspen sucker stimulation.
Data collection
The response variable to be measured is the number of suckers per unit area coming after treatment application. New suckers are expected to develop after treatment imposition. Because browsing suppresses apical dominance, new suckers develop because the plants do not produce sufficient auxin levels to suppress re-sprouting (Schier 1976). For determining number of stimulated suckers, measurements will be made from the same quadrats used for Objective 2. Samples will be collected by randomly placing the quadrat at five different places within each experimental unit. The number of suckers will be counted for each quadrat and expressed as aspen suckers per m$^2$. Measurements will be taken before treatment application for each season, and after treatment application at the end of the LS period for 2 years.

Objective 4. To determine the effects of browsing at 4 simulated intensities and 3 seasons on aspen susceptibility to diseases.

Data collection
Aspen, like most other tree species is prone to disease infections (Baker et al. 1993). Disturbance can predispose aspen to infection by diseases, more especially if the clone is decadent (Schier and Campbell 1980). For example, the impact of an outbreak of defoliating insects or foliar fungi can stimulate a clone to produce new sucker sprouts or contribute to mortality if additional stresses are present (Guyon 2004). However, vigorously growing aspen stands are found to be less susceptible to diseases than are decadent ones. For this proposed study, an effort will be made to ensure that only healthy
vigorously growing aspen clones are selected. Never-the-less, the clones will be surveyed for the presence of diseases before treatments are applied. In the proposed study, it is anticipated that the initial (clear-cutting) as well as the various treatment combinations may predispose aspen to disease infection. Therefore, this objective is included to evaluate disease incidence in case diseases do occur. Disease incidence will be evaluated in the same plots as for objectives 2 and 3. The identity and intensity of aspen leaf and stem infected by each disease in each experimental unit will be rated on a 1 to 5 scale, judged by the degree of leaf infection (Harniss and Nelson 1984). Percentage of leaves infected will be estimated visually, and these percentages will be used to place each disease infection into disease classes 1 to 5 as noted above.

Other variables to be assessed

(a) Biomass of aspen suckers.

Data collection

Biomass will be assessed in the same 1-m x 1-m quadrats used for objectives 2 and 3. Measurements for each experimental unit will be taken before treatments are applied and at the LS period for 2 years. Initially, five quadrat measurements will be collected from each of the experimental units using a double-sampling technique as described by Bonham (1989), and at each sampling period. However, sample numbers will be adjusted accordingly as required after determining the level of variability.
(b) Biomass determination of newly stimulated aspen suckers

**Data collection**

Biomass determination for the newly stimulated aspen suckers will be determined from the same quadrats and times as for objective 2 and 3. Treatments application may yet stimulate new suckers. Therefore, depending on treatment, one would expect that variable number of newly stimulated suckers will show for each intensity. Biomass estimation will be evaluated by measuring the basal stem diameters of suckers (Brown 1976). It has been found that stem diameter and total aboveground weight are highly correlated. This procedure allows for estimation of biomass production from basal stem diameter.

(c) Biomass determination of other associated species

**Data collection**

Biomass determination of the associated species is important because there is a possibility that treatment effects predisposed aspen to competition. If there is competition, biomass production of the associated species is expected to change with level of browsing intensity. Biomass for the dominant grasses and forbs will be determined in the same plots where aspen biomass will be evaluated. For each species, biomass will be estimated by the use of the double-sampling technique (Bonham 1989).
Effort will be made to ensure that samples are randomized from each of the experimental unit.
LITERATURE CITED


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*Mr. Tshireletso’s research will necessitate camping at a remote field site during the summer months. Meanwhile, he will need to continue paying rent on his USU-campus apartment in order to keep it available for when he returns to campus for the fall semester. The daily rate shown is the official USU allowance for camping.