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Basal area growth for aspen suckers under simulated browsing on Cedar Mountain, Southern Utah, Western United States of America

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ABSTRACT

The objective of the study was to determine the effects of season and intensity of clipping using simulated browsing on suckers' (*Populus tremuloides* Michx.) basal area growth on Cedar Mountain, Southern Utah, Western United States of America. Three randomly selected stands measuring 70 m x 70 m were clear-felled in mid-July, 2005, and fenced. Simulated browsing treatments of 0%, 20%, 40%, and 60% removal of current year's growth on aspen suckers were randomly applied in early, mid-, and late summers of 2006 and 2007 on permanently demarcated quadrats. Sucker basal area was monitored by measuring basal diameter of individual suckers. These basal diameter measurements were then converted to m²/ha for each quadrat assuming circular diameter of individual suckers. All data for basal area was analyzed as a three-way factorial in a split-split plot design using the MIXED procedure of SAS. Basal area growth for early (172%±24%) summer treated plots was significantly ($P<0.05$) higher than for mid- (60%±20%) and late (70%±20%) summer treated plots that did not differ, between 2006 and 2007. Change in basal area growth for intensity 0% (1.94±0.31 m²/ha) was higher ($P<0.05$) than for 20% (0.78±0.31 m²/ha), 40% (0.21±0.31 m²/ha) and 60% (0.36±0.31 m²/ha) in 2006. Browsing in mid- and late summer the year following clear-felling operation would result in reduced sucker basal area growth of the suckers than browsing in early summer. Grazing programs that ensure use the first month of the growing season the year following clear-felling operation would ensure increased sucker basal area growth.

Keywords: Aspen, basal area growth, browsing intensity, browsing season, *Populus tremuloides*.

INTRODUCTION

Decline of aspen (*Populus tremuloides* Michx.) stands on Western landscapes of the United States of America has been widely documented (Campbell and Bartos, 2001; Hessel and Graumlich, 2002). The factors contributing to this decline are varied and difficult to separate (Kay, 1997; Bartos and Campbell, 1998) and the decline has been attributed to excessive browsing of reproductive suckers by ungulates (Kilpatrick and Abendroth, 2001). However, little is known about the particulars of the response, especially how it is affected by intensity and season of browsing.

Browsing on most plant species is most detrimental during the early and late

growing seasons depending on the amount of plant tissue removed (Cook, 1971; Bergström and Danell, 1987). In the early stages of growth, plants utilize most of the storage reserves into the physiological processes required by the recently dormant plant, while late summer browsing does not allow plants sufficient time to harden off to withstand the winter conditions (Dockrill *et al.*, 2004). Research has also shown that repeated ungulate browsing even if plant height is restricted, basal diameter may increase (DeByle, 1985; Keigley and Frisina, 1998).

Aspen systems are important ecologically on Western landscapes of the United States of America as they support other associated under-story vegetation. They support high

biodiversity of plants and sufficient basal area of trees minimizes soil erosion in these high elevation areas.

Woody plants' characteristics allow them to tolerate some level of browsing (Bilbrough and Richards, 1993; Boege and Marquis, 2005) and their growth is controlled by hormones that suppress lateral growing points while maintaining apical dominance (Haukioja and Koricheva, 2000). However, these responses may be affected by the intensity of browsing. At low or moderate grazing intensity, the plant may be stimulated to produce well above the lost tissue amount (Belsky, 1986). However, few studies have attempted to document the effects of browsing impacts on aspen basal area growth with respect to timing and intensity of browsing. The specific objective of the study was to determine the effects of simulated browsing at four intensities and three seasons on aspen sucker basal area growth under natural environmental conditions.

MATERIALS AND METHODS

The study was located on privately owned land on Cedar Mountain, approximately 27 km southeast of Cedar City, Southern Utah, Western United States of America. Mean annual precipitation for the study site averaged 711 mm from 1970 to 2007 and annual precipitation during the study was 1,323 mm, 640 mm, and 810 mm for 2005, 2006, and 2007, respectively. Long-term (1992-2007) average temperature ranged from -3.5 °C in January to a day-time maximum of 15.9 °C in July. Soils are Argic Pachic Cryoborolls, with fine montmorillonitic fawn clay loam, with slopes of 0-28% (Bowns and Bagley, 1986). The vegetation consists of interspersed mountain grasslands and woodlands of trembling aspen, with patches of Gambel oak (*Quercus gambelii* Nutt.) (Ohms, 2003) and the dominant grasses are Letterman needlegrass (*Stipa lettermani* Vasey) and Kentucky bluegrass (*Poa pratensis* L.).

Major browsers of the area include cattle, deer, elk and sheep.

During late spring of 2005, three aspen stands measuring 70 m x 70 m were randomly selected on the research area located at lat. 37°29'652"N and long. 112°56'247"W. These stands were clear-felled in mid-July and logs were immediately hauled off-site using a front loader equipped farm tractor. Tree apical dominance removal and soil disturbance by the tractor stimulated immediate sucker emergence. The cleared stands were immediately fenced with a 3-m high game-proof black plastic mesh fence to protect suckers from ungulate browsing. The fence was laid down in late fall of 2005 just before the snowfall to prevent it from being crushed by the snow. It was replaced in late spring of 2006 as soon as the area was accessible by vehicle. It was assumed that suckers would remain covered and protected by snow through the winter, thus incurring minimal browsing during this period. However, most 2005 suckers were browsed in early spring before the fence could be replaced. For this reason, the fence was left standing at the end of the growing season in 2006 and held well over the winter.

In June 2006, each stand was divided into three roughly equal portions and each was randomly assigned to one of the three clipping seasons i.e. early (ES), mid (MS) and late (LS) summer, respectively. In each portion, four line transects measuring about 70 m were established, running the entire length of the stand. These transects were placed such that each one had a buffer zone of at least 2 m. The simulated browsing intensities were 0%, 20%, 40%, and 60% removal of current season's growth were then randomly assigned to the line transects. Along each transect, 15 1.0-m² square shape permanent quadrats were established, utilizing the nearest plant method (USDI, 1996) for monitoring aspen suckers, with the sucker identified serving to locate the center of the quadrat. Quadrats were permanently marked and labeled.

Simulated browsing treatments were applied to the all suckers in a quadrat in early ES; 15 June, MS; 30 July, and LS; 15 September, using the ocular estimation method (Bonham, 1989), imposed on each current year's branch of each sucker. The same plots (suckers) were clipped in 2006 and 2007. To minimize the chance occurrence of spreading pathogens between suckers, the hand clippers were dipped into 70% alcohol before a new sucker was clipped. Basal diameter of individual suckers was measured using calipers and basal area was calculated as πr^2 where r was the radius of the base of the sucker, in cm. Basal area of individual suckers, were then summed to give total basal area at each quadrat (cm^2/m^2) and then converted to m^2/ha .

Factors analyzed statistically included three seasons, four clipping intensities, two sampling times (referred to as "time" in the figures) and their interactions. Sampling time designated when measurements were made, i.e., at the beginning of a season before any clippings were made, and at the end of the growing season. Specifically, times B06 and B07 refer to before clipping in 2006 and 2007, respectively. E06 and E07 refer to the end of the growing season in 2006 and 2007, respectively.

All data for basal area was analyzed as a three-way factorial in a split-split plot design with whole plots in blocks by analysis of variance (ANOVA) using the MIXED procedure of SAS (SAS/STAT software, Version 9.1.3 of the SAS System for Windows 2002-2003. Copyright © SAS Institute Inc.). Whole plots were seasonally designated portions of the stand nested within sites (blocks), and the whole plot factor was season (3: early, mid-, late summer). Subplots were transects within the designated portions of the stand, and subplot factor was intensity (0%, 20%, 40%, 60%). Repeated measures on the transects were the sub-subplots, and the sub-subplot factor was time (B06, B07, E06, E07). Fixed effects included season, intensity,

sampling time or year, and their interactions. Sites were considered random effects. Basal area zero values were treated as missing data in the analyses. Multiple comparisons of the least square means for the fixed effects were made using the Least Significance Difference procedure of SAS. Differences were considered significant at $P < 0.05$.

RESULTS

Effects of intensity and season of clipping on first year's basal area growth

Overall, basal area of suckers increased from time B06 to B07. Basal area growth of suckers was numerically lower though not significant ($P > 0.05$) in early summer compared to mid- and late summer season at time B06 (Fig. 1), demonstrating that suckers were continuously growing. Although basal area for early summer plots was less than for the other seasons at time B06, basal area for early summer plots were not statistically different from mid- and late summer plots by time B07. Apparently, intensity of clipping did not significantly affect basal area of suckers.

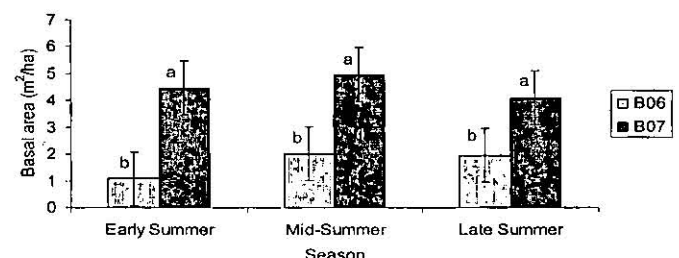


Figure 1. Mean comparisons of basal area before clipping in Southern Utah, Western United States of America during 2006 and 2007, for three seasons. B06, B07 = before suckers were clipped at the beginning of seasons in 2006, and 2007, respectively. Bars indicate standard errors. Means with different letters are significantly different at $P < 0.05$.

Effects of repeated clipping and season of clipping on basal area growth

Basal area of suckers was not affected by season of clipping at time E06, but season of clipping affected basal area at time E07 (Fig.

2). Clipping in mid- and late summer limited basal area growth of suckers compared to clipping in early summer by time E07. Notably, clipping in early summer resulted in a $172\% \pm 24\%$ increase in basal area, while clipping in mid- and late summer resulted in an increase of around $60\text{--}70\% \pm 20\%$ in basal area, between the two times. However, clipping intensities did not significantly affect basal area growth.

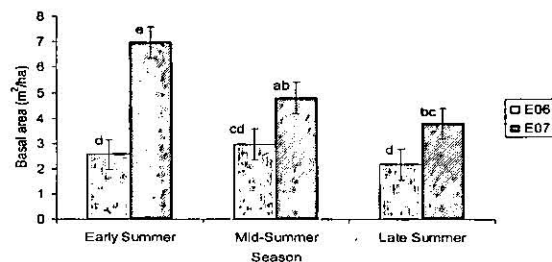


Figure 2. Effect of season of clipping on mean basal area at the end of the growing season in 2006 (E06) and 2007 (E07), respectively in Southern Utah, Western United States of America. Bars indicate standard errors. Means with different letters are significantly different at $P < 0.05$.

Differences between 2006 and 2007 sucker basal area growth

Intensity and year interacted for change in basal area (Fig. 3). Clipping affected basal area growth in 2006, compared to the control. Basal area growth for the intensity 0%, 20%, 40% and 60% was 0.97 ± 0.31 , 0.68 ± 0.31 , 0.04 ± 0.31 and 0.05 ± 0.31 m^2/ha , respectively, lower in 2007 than in 2006. However, in 2007, clipping did not statistically affect basal area growth differently from the control, though there was a tendency for the control suckers to be numerically higher than for the clipping intensities. Meanwhile, season of clipping did not significantly affect change in basal area. Averaged across the three seasons, basal area growth was approximately 0.8 ± 0.3 m^2/ha and 0.4 ± 0.3 m^2/ha in 2006, and 2007, respectively.

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Figure 3. The effect of clipping intensity on mean basal area changes for 2006 and 2007 in Southern Utah, Western United States of America. Bars indicate standard errors. Means with different letters are significantly different at $P < 0.05$.

DISCUSSION

In this study basal area growth was affected ($P < 0.05$) by both season (Figs. 1 and 2) and intensity of clipping (Fig. 3). Usually, tree basal area is used as a measure of site occupancy in forest management (Jones *et al.*, 1985). In general, basal area growth tracked sucker density changes (Tshireletso, 2008). By the beginning of the second growing season, basal area for suckers clipped in early summer (2006) was similar to mid- and late summer (2006) clipped suckers and had roughly doubled in amount from that observed one year earlier. This finding could be attributed to minimal or no winter mortality for early summer clipped plots than for mid- and late summer clipped plots that experienced considerable mortality (Tshireletso, 2008). These trends in basal area growth were not surprising, since diameter growth for aspen suckers usually increases considerably with reduced competition for resources among suckers, as a result of mortality (Jones *et al.*, 1985).

In the first growing season, clipping was detrimental to basal area growth regardless of intensity compared to the control (Fig. 3), refuting the hypothesis that clipping limits growth more as the intensity of clipping increases. These results were consistent with other clipping studies on woody plants. For example, Saunders and Puettmann (1999) reported reduced diameter growth (implying reduced basal area growth) for white pine seedlings clipped at 50% and 100% of current year's growth compared to the control. However, with passing time, even though browsing continues, basal area usually increases (DeByle, 1985; Keigley and Frisina, 1998), but sucker height may be restricted. In this study, basal area growth for the control was significantly higher in

2006 than in 2007, probably an indication of adjustment in root/shoot ratio as the suckers aged (Jones *et al.*, 1985; Campa *et al.*, 1992).

CONCLUSION AND MANAGEMENT IMPLICATIONS

Basal area of suckers treated in early summer was lower than for mid and late summer treated plots in year one. By the beginning of the growing seasons in year two, basal area growth for all seasons of clipping were not different. However, by the study's end basal area growth for suckers clipped in early summer was significantly higher than for late summer

treated plots. From an aspen restoration standpoint, designing grazing programs that delay use for at least two months of the growing season the year following clear-felling operation would ensure sustained stand development even though basal area growth would be reduced. Additionally, it is recommended that a protocol be developed to monitor suckers' basal area growth responses to browsing.

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