TREE SAPLING AND SHRUB HEIGHTS AFTER 25 YEARS OF LIVESTOCK GRAZING IN GREEN ASH DRAWS IN WESTERN NORTH DAKOTA

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ABSTRACT

Stem heights of green ash and American elm saplings and five shrub species were measured over 25 years with two treatments, 1) livestock present and 2) livestock excluded from woodland draws in western North Dakota. Heights of green ash and American elm saplings and Saskatoon serviceberry, spiny current, and western snowberry increased when livestock were excluded. Common chokecherry was taller throughout the 25-year period on the grazed treatment. Wood's rose was the exception and decreased overall under both treatments, but was generally taller on the ungrazed treatment. Significant differences in stem heights were observed between treatments within 3-4 years after livestock were excluded; wildlife could graze both treatments. All American elm saplings died within livestock grazed sites during the study, but heights increased 22% over this period when livestock were excluded. Green ash saplings experienced a growth rate five times greater when cattle were excluded. Saskatoon serviceberry and common chokecherry experienced stem growth rates 2-5 times greater, respectively, when livestock were excluded.

Keywords

Woody draws, grazing, shrubs, Northern Great Plains, North Dakota

INTRODUCTION

The sustainability of green ash/American elm woodland systems on the Northern Great Plains has been a concern of land managers for a long time. Woodlands confined to draws occupy a small percent of the land area (Jakes and Smith 1982). These woodland systems have been an important component for livestock and wildlife use by providing food, cover, and protection during the winter months (Severson and Boldt 1978, Bjugstad and Girard 1984, Kauffman and Krueger 1984, Bjugstad and Sorg 1985, Hodorff et al. 1988, Uresk 1982). Human involvement in the natural processes over the past century has altered

woodland ecosystems and many are in stages of decline because of age, overuse, fire suppression, and disease (Severson and Boldt 1978, Boldt et al. 1978). As mature trees become decadent or diseased they are replaced by saplings, shrubs, grasses, and forbs (Severson and Boldt 1978, Boldt et al. 1978). The plant community that replaces the contemporary woodland community depends partially on management. Saplings must survive to replace the current trees while competing with shrub and herbaceous species for the same available resources. Tree saplings that exceed 160-180 cm heights have a greater probability of survival because the apical meristem exceeds the height of livestock and wildlife browse (Uresk and Boldt 1986). Livestock and wildlife grazing can result in decreased height, plant vigor, and cover, damaged plants, alteration of plant communities and species composition of shrubs and tree saplings (Garrison 1953, Ellison 1960, Willard and McKell 1978, Uresk 1987). The objectives of this study were to evaluate the response of tree sapling and shrub heights to livestock grazing compared to areas where livestock were excluded over a 25 year period and to report general trends and observed growth rates.

STUDY AREA

The study was on the Little Missouri National Grasslands, Dakota Prairie National Forest, in southwestern North Dakota. Climate is cool-temperate, semi-arid, with wide variations of temperature and precipitation (Omodt et al. 1968). Average annual precipitation for a 30-year period between 1971 and 2001 was 38 cm (15 in.). Woodlands sampled were located in drainages surrounded by upland grasslands northwest of Dickinson, North Dakota. Woodlands selected were predominantly of green ash (*Fraxinus pennsylvanica*) and lesser amount of American elm (*Ulmus americana*). These stands averaged 480 live trees per hectare and consist of 60% green ash, 38% American elm and 2% other trees (Uresk and Boldt 1986). The shrub understory included western snowberry (*Symphoricarpus occidentalis*), Wood's rose (*Rosa woodsii*), spiny currant (*Ribes setosum*), Saskatoon serviceberry (*Amelanchier alnifolia*), common chokecherry (*Prunus virginiana*), and lesser amounts of silver buffalo berry (*Shepherdia argentea*), American plum (*Prunus americana*), hawthorn (*Crataegus* spp.), and raspberry (*Rubus* spp.). Common grass and grass-like species included Kentucky bluegrass (*Poa pratensis*) and sedges (*Carex* spp.) (Boldt et al. 1978).

The woodland study area was in two pastures grazed by cattle in a three pasture allotment under a deferred rotation grazing system. Stocking rate was 1.1 AUM's ha^{-1} (animal unit months) from May 15 to October 30. Pastures were originally managed for season long grazing as a single pasture, but converted to a three pasture deferred system in 1972, two years before the study started.

METHODS

Six sites (0.08 ha) were randomly selected within several woodland draws (Boldt et al. 1978) and included cattle grazing (3 sites) versus exclusion from

cattle grazing (3 sites). Wildlife was present in both treatments. Fence construction to exclude cattle was completed by the fall of 1975. Data were collected during the end of the growing season each year. Initial measurements were collected in 1975 and additional measurements were collected for six subsequent years (1976-1981) and a final time in 2001. Heights of green ash and American elm saplings (less than 2.5 cm DBH) and the five shrubs—Saskatoon serviceberry, common chokecherry, spiny current, Wood's rose, and western snowberry—were measured within five randomly located 15.3 meter by 1.2 meter belt transects at each sample site. Transects were permanently marked with metal rebar to allow re-sampling. Plant heights were measured to the nearest cm, averaged by site, and then treatment.

Data were analyzed with analysis of covariance (SPSS 2003) using the first year data (1975) as the covariate. Results were considered significant at $\alpha \leq 0.15$, unless otherwise stated. Analysis of variance tests were used to test for treatment differences when the covariate lacked significance. Adjusted means were used to calculate growth rates (Table 1). Growth rates were estimated by subtracting heights recorded in year 1 (1976) from 1981 heights and then heights recorded in 1981 (year 6) from the final year data (2001); these differences were then divided by number of years (6, 19 respectively).

Precipitation data were averaged for the years 1971-2001 in order to compare annual precipitation to a 30-year average for three weather stations located close to the study area. The weather stations were located at Farifield, Trotters, and Watford City in North Dakota (HPRCC 2009).

RESULTS

General trends show all stem heights except Wood's rose increased after 25 years without livestock grazing when compared to year 1 (Figure 1). With livestock grazing green ash saplings were nearly equal after 25 years when compared to year 1 with livestock grazing. Four species (Saskatoon serviceberry, snowberry, Wood's rose, and American elm) decreased from the initial height after 25 years with livestock grazing. Height variability among years was large and often followed similar increases or decreases regardless of treatment. The exception was American elm where the height after the third year began a decrease and was zero by 2001 on sites with livestock grazing. This decline was the result of all American elm saplings dying within the grazed belt transects. Significant height differences were generally observed 3-4 years after cattle were excluded. Spiny current showed an increase in stem height after 25 years on both grazed and ungrazed treatments. Most growth occurred after the second year of post-treatment measurements.

Saskatoon serviceberry heights were significantly greater on the ungrazed treatment compared to the grazed area for year 4, 5, 6, and 25 (Figure 1). There was an overall increase of 18 cm in average height on the ungrazed treatment for all years, approximately 24% greater when compared to the grazed treatment ($P \leq 0.15$). A mean height of 109 cm was measured on the ungrazed treatment in the 25th year, which is 44% greater when compared to the mean height of the

grazed treatment (61 cm). The growth rate for serviceberry was 3-5 times greater when livestock grazing was excluded (Table 1).

Common chokecherry heights were greater on the grazed treatment over the 25- year period when compared to the ungrazed treatment but growth rates were greater on the ungrazed treatment (Figure 1). Chokecherry height increased 46 cm from the sixth year to the 25th year with a mean of 68 cm on the ungrazed sites ($P \leq 0.10$) the final year. Growth rates for chokecherry were twice as great on livestock excluded sites compared to sites with livestock (Table 1).

The heights of spiny current for both treatments showed a marked increase the 25th year when compared to year 6. Both treatments also showed substantial increases in the 25th year when compared to year 1 (Figure 1). Spiny current was the only species that lacked significant differences in height any year and showed an increase trend in height after 25 years under livestock grazing when compared to year 1. Growth rates were similar.

Wood's rose was the only shrub measured where average height was less in year 25 compared to year 1 for both treatments (Figure 1). However, heights were significantly taller on the ungrazed treatment during year 4 to year 25. Overall, the average heights on the ungrazed and grazed treatments were 53 cm and 47 cm, respectively. Growth rates were negative, but twice as great without livestock grazing over the 25-year period. The first six years showed an overall decline, but positive growth rates were observed during the last 19 years for both treatments (Figure 1, Table 1).

Significantly greater heights were observed for western snowberry on the ungrazed treatment the forth, fifth and the 25th year. Stem heights increased where livestock were excluded and decreased where livestock grazed when compared year 1 to 25 (Figure 1). Growth rates for snowberry were similar during the last 19 years for both treatments (Table 1).

Heights of green ash saplings were greater from the third year to the 25th year when livestock were excluded compared to livestock grazed areas (Figure 1). Average heights of 164 cm and 66 cm were observed after 25 years on ungrazed and grazed treatments, respectively. The heights of the saplings were very similar to their heights at year 1 compared to year 25 on the grazed treatment. Growth rates were at least 4 times as great on the ungrazed sites when compared to the livestock grazed sites (Table 1). In shelterbelts on the Great Plains, green ash can experience growth rates of 40 cm per year and generally a greater rate when young (Wright 1965); the average annual rate observed in our study exceeded 4 cm annually (Figure 1, Table 1).

Stem heights of American elm were consistently greater on ungrazed sites when compared to grazed sites in 1978 and 2001 (Figure 1). No live American elm saplings were recorded on the grazed treatment in the 25th year. Generally, growth rates were positive when livestock were excluded and negative with livestock grazing.

DISCUSSION

The long-term succession of green ash/American elm woodlands is generally a slow process and may be altered with variations of livestock management

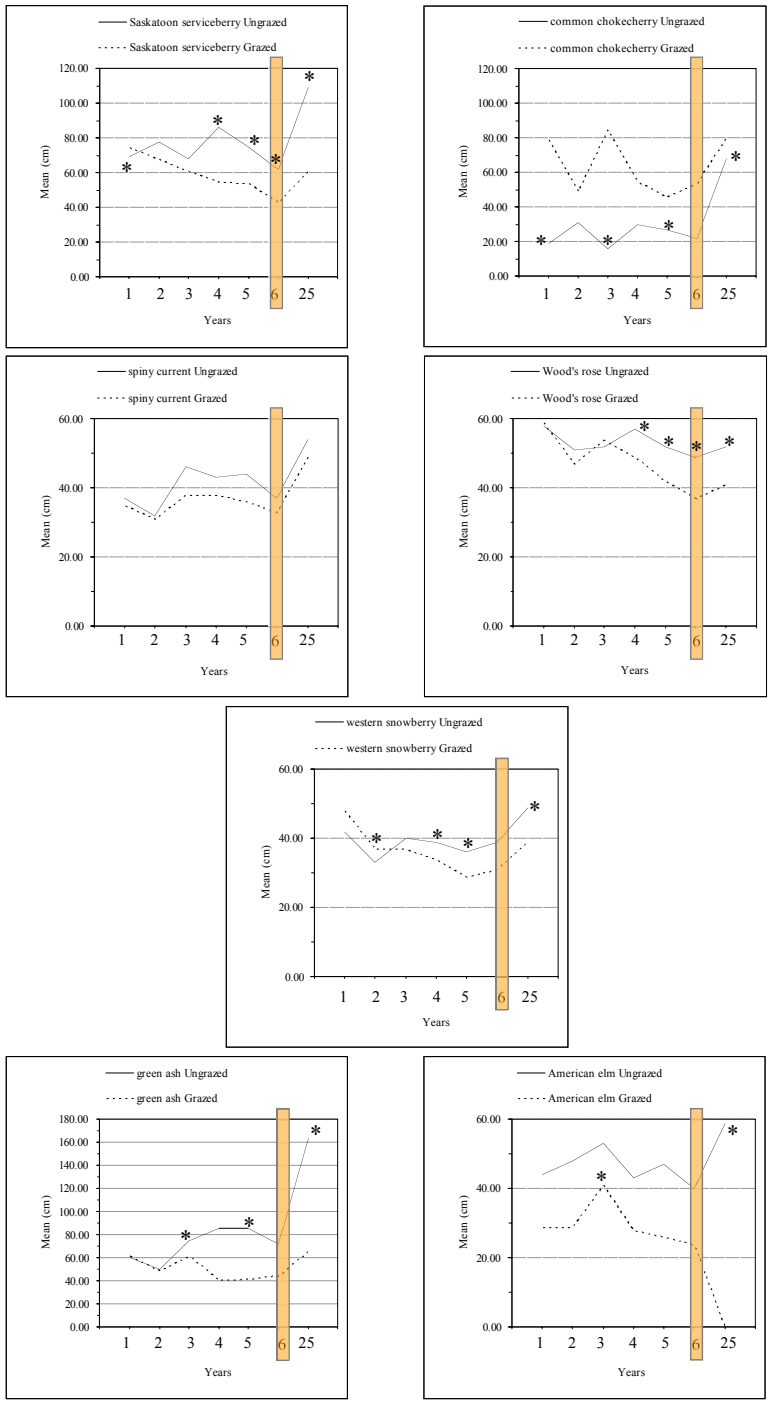

Figure 1. Response of woody plants over a 25-year period. Means are adjusted by covariance analysis and treatment differences are significant at α = 0.15 as indicated by * . The species are: Saskatoon serviceberry, common chokecherry, spiny current, Wood's rose, western snowberry, green ash, and American elm.

Table 1. Growth rates (cm) of shrub species and tree saplings for 2 periods (1st six years and last 19 years) and an overall growth rate calculated with adjusted means.

	Saskatoon serviceberry Ungrazed	Saskatoon serviceberry Grazed	common choke-cherry Ungrazed	common choke-cherry Grazed	spiny current Ungrazed	spiny current Grazed	Wood's rose Ungrazed	Wood's rose Grazed	western snowberry Ungrazed	western snowberry Grazed	green ash Ungrazed	green ash Grazed	American elm Ungrazed	American elm Grazed
Year 25-year 1	40	-14	49	1	17	14	-6	-18	7	-9	104	4	15	-29
Year 6-year 1	-7	-32	3	-25	0	-2	-9	-22	-3	-17	12	-17	-4	-5
Year 25-year 6	47	18	46	26	17	16	3	4	10	8	92	21	19	-24

(Boettcher and Johnson 2005). Shrub species in our study responded differently to grazed and ungrazed treatments in this three pasture, deferred rotation grazing system. Heights were greater for four of the shrub species (Saskatoon serviceberry, spiny current, Wood's rose, and common snowberry) after several years with no livestock grazing when compared to the livestock grazed areas, and common chokecherry increased, but remained shorter than what was observed on the grazed sites.

Green ash and American elm were observed to have greater sapling heights after several years on livestock excluded sites when compared to sites grazed by livestock. Woody draws with proper livestock grazing should be managed to protect the understory shrubs and saplings while providing a shady environment (Lesica 2009). Common chokecherry showed an overall increase in height on the livestock excluded sites after 25 years and remained about the same height with cattle grazing when year 1 was compared to year 25 (Figure 1).

Green ash and American elm showed an increased response in height when released from livestock grazing. Probably all the American elm saplings within the belt transects on livestock grazed sites died from the combined stress of livestock and Dutch elm disease (Stack and Laut 1986). The decline in American elm height on grazed sites probably shows a combined impact of diseased saplings and stress from livestock grazing when compared to saplings on the livestock excluded sites. The lack of American elm regeneration (loss of saplings) is partially due to time since exposure to disease, elimination of adult trees, available moisture, regeneration opportunities, competition with other species (Huenneke 1983) and impacts of livestock grazing.

Seasonal use of shrubs by livestock and the type of grazing system can influence the growth of shrubs. Livestock use of shrubs generally increase with increased

maturity of herbaceous vegetation (Boettcher and Johnson 2005, Holechek et al. 1982, Roath and Krueger 1982). Moderate or light use by livestock of many shrubs may result in greater vegetative growth than with no use (Garrison 1953, Ellison 1960), however, if greater vegetative growth occurred with livestock grazing in our study we failed to observe it as stem height.

All species except American elm experienced positive growth during the last 19 years of the study. Precipitation was recorded to be above the 30-year average (38 cm) during ten of the last eleven years of the study (Figure 2). Greater annual precipitation could contribute not only to greater stem growth, but to greater herbaceous production nearby that may have reduced livestock's utilization of woody plants during the last decade of the study.

Four shrubs (Saskatoon serviceberry, spiny current, Wood's rose, and western snowberry) managed under a three pasture, deferred rotation grazing system generally resulted in taller plants on the livestock excluded sites after a few years and were greater after 25 years compared to sites with livestock grazing. Common chokecherry was taller throughout the 25-year period while being grazed. Saplings of green ash and American elm exhibited greater heights when not grazed by cattle.

Livestock grazing, even in a three pasture, deferred rotation management system, generally showed a decrease or little change in stem heights for all shrubs and tree saplings. Management for increased height of saplings and shrubs could improve wildlife habitats and provide increased opportunity for sapling recruitment in these woodland draws.

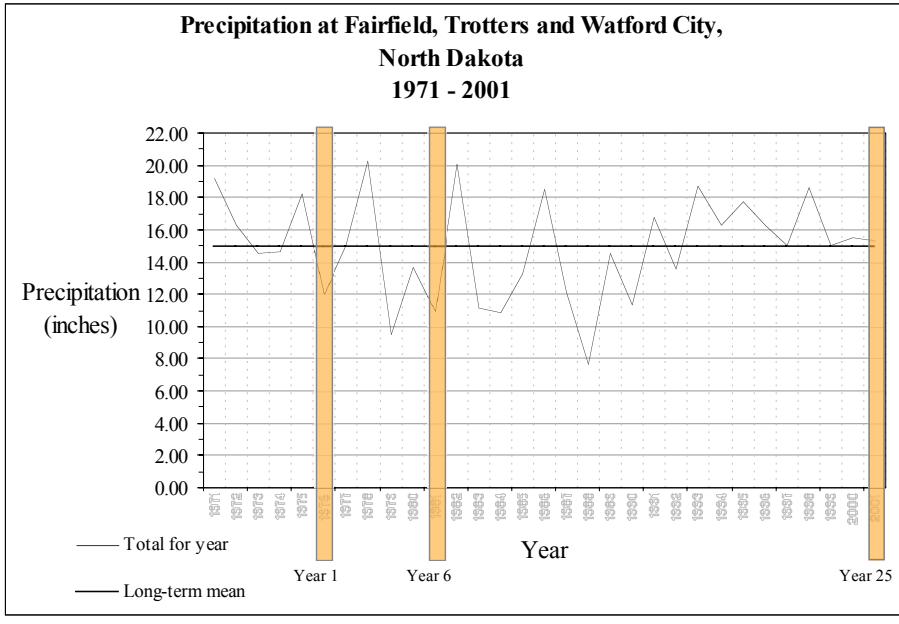

Figure 2. Thirty year precipitation average (horizontal line) for the study area in western North Dakota with annual average precipitation plotted for comparisons. The annual precipitation was averaged by combining data from three weather stations nearby the study area (HPRCC 2009).

Over a post-treatment period of 25 years, shrubs managed under a three pasture, deferred rotation grazing system generally responded in taller plants on the ungrazed treatment after a few years. Four shrubs—Saskatoon serviceberry, spiny current, Wood's rose, and western snowberry—were taller when ungrazed. However, common chokecherry was taller throughout the 25-year period while being grazed. Saplings of green ash and American elm exhibited greater heights when not grazed. Livestock grazing generally caused a decrease in stem heights for most shrubs and trees.

Although, management for increased height of all shrubs would be important to wildlife, shrubs also provide livestock with protection during periods of inclement weather. Monitoring changes in stem heights of shrubs and trees would be difficult because of the high variability. Alternatively, field application for monitoring green ash woodlands may be obtained on the USDA Forest Service Rangelands web site from: (http://www.fs.fed.us/rangelands/ecology/ecologicalclassification/index.shtml).

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