

# Effect of Cultural Treatments on Regeneration of Native Woodlands on the Northern Great Plains

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**ABSTRACT** — Two cultural treatments were evaluated over a 6-year post-treatment period to determine their effect on regeneration of native woodlands in southwestern North Dakota. Cultural treatments included livestock exclusion and the combination of felling and removal of low-vigor trees and transplanting of woody plants. Shrub density varied by species when grazed and ungrazed treatments were compared. American elm (*Ulmus americana*) increased on grazed areas. Thinning and removal of decadent tree stems stimulated sprout regeneration of green ash (*Fraxinus pennsylvanica*) and American elm, and resulted in increased densities of seedlings. Survival of trees increased with sprouting even on grazed stands. Transplanting of woody plants was successful, and when grazing was excluded, survival of plants improved by about 36%.

Riparian-like woodlands are composed of deciduous trees and shrubs and occupy less than 1% of the land area on the northern Great Plains (Jakes and Smith 1982). There is considerable evidence that these woodlands are becoming decadent, with most trees rotten, broken, and snag-topped; some woodlands have disappeared and have been replaced by grasses and forbs (Severson and Boldt 1978, Boldt et al. 1978). Many of these woodland stands are in advanced stages of breakup, with small scattered stands of shrubs and trees found in the draw systems.

Woodlands, in comparison to open prairies, are important to livestock in providing shade, thermal cover, escape from wind and insects, and increased quality and quantity of forage (Severson and Boldt 1978, Kauffman and Krueger 1984, Bjugstad and Girard 1984). Improper grazing can result in decreased vigor of plants and alteration of species (Garrison 1953, Willard and McKell 1978, Ellison 1960). However, livestock grazing is not the only major impact on these woodlands. Many of these shrub-tree stands are degenerating because they are near the end of their life spans (Boldt et al. 1978). Old stands become vulnerable to further damage by insects, disease, and humans. Other factors that may influence long-term changes in these woodlands are construction of livestock ponds (which influences the hydrology), climate, geology, soils, plant succession, and protection from wildfire.

The objectives of this study were to determine the response of shrubs and trees in the northern Great Plains (1) to livestock grazing and exclusion of graz-

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ing, and (2) in unthinned woodlands and thinned woodlands in which low-vigor trees were removed and woody plants transplanted.

## STUDY AREA AND METHODS

The study was conducted on the Little Missouri National Grasslands, Custer National Forest, in southwestern North Dakota. A woodland system was selected in the upper reaches of Magpie Creek drainage near Belfield. Trees in these prairie drainages were green ash (*Fraxinus pennsylvanica*) and American elm (*Ulmus americana*). A shrub understory included western snowberry (*Symphoricarpus occidentalis*), Woods rose (*Rosa woodsii*), spiny currant (*Ribes setosum*), Saskatoon serviceberry (*Amelanchier alnifolia*), silver buffaloberry (*Shepherdia argentea*), common chokecherry (*Prunus virginiana*), American plum (*Prunus americana*), hawthorn (*Crataegus* spp.), and raspberry (*Rubus* spp.).

Woodlands selected for study were in two pastures grazed by cattle in a three-pasture allotment under a deferred rotation grazing system. Stocking rate was 1.07 AUM's/ha (animal unit months) from May 15 to October 30. Utilization of forage by late August-early September averaged 35 %. At the start of this study, the pastures had been managed for two years under this system; before then, the area had been grazed season-long as a single pasture.

Twelve sample sites (0.08 ha each) were selected at scattered locations throughout a major wooded draw system (Boldt et al. 1978). The experiment included two factors in a factorial design, cattle grazing versus no grazing, and felling and removal of trees (cut)-planted versus no tree removal (uncut)-not planted. The four treatment combinations were allocated at random to the 12 sites, with three replications per treatment. Fences to exclude cattle were installed in late summer and fall of the first year.

Pretreatment and post-treatment measurements were collected for shrubs and small trees on all sites during late August and early September of each year. Pretreatment measurements were collected the first year. Densities of shrubs and small trees (less than 2.5 cm DBH) were individually measured on five 15.3 x 1.2 m belt transects randomly located on each site. Post-treatment measurements were collected on all sites for six subsequent years.

Plots designated for tree felling and removal were selectively cut (40% of total tree stems) to open the canopy and stimulate sprouting (Boldt et al. 1978) during the first year. Decadent trees with low vigor – rotten, broken, and poorest of the growing-stock as described by Boldt et al. (1978) – were felled and removed. Tree composition on each of the 12 sites was determined both before and after tree removal. Fifteen tree stumps from each site were randomly selected to obtain number of sprouts per stump and height of sprouts each year.

Containerized tree and shrub seedlings were planted on the thinned tree plots in spring of the third year (second post-treatment year). Six species were planted: green ash, Rocky Mountain juniper (*Juniperus scopulorum*), bur oak (*Quercus macrocarpa*), common chokecherry, American plum, and Russian olive (*Eleagnus angustifolia*). Twenty-four containerized seedlings of each species were planted in each of the six partially cut sites on herbicide-treated (2,2-dichloropropionic acid) spots. All species and containerized pots were ran-

domly distributed throughout a fixed (systematic) lattice pattern with a 2 x 3 m spacing.

Understory standing crop estimates during the last three years of the study were obtained by clipping 20 (3 l-cm x 6 l-cm) quadrats at ground level for 12 sites in August. Grasses, including sedges, and forbs were separated, oven-dried for 48 hr, and weighed to the nearest 0.1 g. Differences in weights between grazed and ungrazed herbage were expressed as percent use.

Shrub densities and height measurements by species were averaged by site for statistical analyses. Analysis of covariance, using the first year's data as the covariate, was used to test treatment effects separately for each species each year (Hull and Nie 1981). When the covariate was not significant ( $\alpha = 0.10$ ), an analysis of variance was used to test for treatment differences. The level for each individual test used a conservative Bonferroni criterion of  $\alpha = 0.04$  for an individual species and year combination. This  $\alpha$ -level was derived from an overall  $\alpha$ -level (experiment-wise error level) of 0.25 for each species for the six post-treatment years of the study (Miller 1981). However, when individual years are considered without the  $\alpha$  level divided by six, more differences occurred; thus, the term biological trend is used in the text.

Chi-square analysis (2x2) was used to test for differences in percent survival of shrub and tree plantings, stand composition, and stump sprouts. T-tests were used to evaluate differences between two grazing conditions for the number of sprouts per stump, height of clump sprouts, heights of planted trees and shrubs, and plant standing crop. All significant levels were at  $\alpha = 0.10$ , unless stated otherwise.

## RESULTS

### Stand Composition and Partial Cutting

The overstory trees consisted of 60% green ash ( $286 \pm 37/\text{ha}$ ,  $\pm$  SE), 38% American elm ( $185 \pm 67/\text{ha}$ ), and approximately 2 % other trees ( $10 \pm 5/\text{ha}$ ). Approximately 40% of the original overstory tree stems, which included highly defective and decadent trees, were cut.

Nearly all stumps from cut trees produced sprouts the year after tree removal (Table 1). By the end of the fifth growing season, 13% of the stumps did not have sprouts on the grazed sites compared to 7% on the ungrazed sites. The number of sprouts produced per stump on the grazed sites was greater during the fifth year than on the ungrazed sites. However, average heights were lower on the grazed sites. After five years, average height of tallest sprouts was 21 dm on ungrazed sites versus 9 dm on the grazed sites. Average height of the tallest sprouts was significantly lower on grazed sites.

### Planting

After five growing seasons, survival and heights of individual plant species were generally significantly greater when not grazed by livestock (Table 2). After three years, green ash plants had 72% and 38% survival on ungrazed and grazed sites, respectively. Rocky Mountain juniper had the highest survival of the six species planted on both grazed and ungrazed sites. Russian olive had the lowest

Table 1. Measurements of tree stumps with sprouts ( $\pm$  standard error) from one to five years following treatment in woodlands on grazed and ungrazed plots.

| Item                            | Post-treatment<br>year | Treatment  |             |
|---------------------------------|------------------------|------------|-------------|
|                                 |                        | Ungrazed   | Grazed      |
| % stumps with sprouts           | 1                      | 98 $\pm$ 2 | 100 $\pm$ 0 |
|                                 | 3                      | 95 $\pm$ 2 | 95 $\pm$ 3  |
|                                 | 5                      | 93 $\pm$ 4 | 87 $\pm$ 7  |
| x no sprouts/stump              | 3                      | 14 $\pm$ 1 | 17 $\pm$ 2  |
|                                 | 5                      | 13 $\pm$ 1 | 16 $\pm$ 1* |
| x height of clumps (dm)         | 3                      | 11 $\pm$ 1 | 6 $\pm$ 2*  |
|                                 | 5                      | 16 $\pm$ 1 | 6 $\pm$ 2*  |
| x height of tallest sprout (dm) | 3                      | 16 $\pm$ 1 | 9 $\pm$ 2*  |
|                                 | 5                      | 21 $\pm$ 1 | 9 $\pm$ 3*  |

\*Significantly different at  $\alpha = 0.10$ .

Table 2. Survival and height ( $\pm$  standard error) of planted trees and shrubs on grazed and ungrazed plots after five years.

| Species                 | 96 Survival |              | Heights (dm)  |                |
|-------------------------|-------------|--------------|---------------|----------------|
|                         | Ungrazed    | Grazed       | Ungrazed      | Grazed         |
| Green ash <sup>1/</sup> | 72 $\pm$ 7  | 38 $\pm$ 5*  | 4.2 $\pm$ 0.3 | 3.0 $\pm$ 0.3* |
| Rocky Mountain juniper  | 88 $\pm$ 3  | 61 $\pm$ 6*  | 4.4 $\pm$ 0.5 | 3.9 $\pm$ 0.2  |
| Bur oak                 | 82 $\pm$ 5  | 44 $\pm$ 6*  | 2.8 $\pm$ 0.4 | 1.2 $\pm$ 0.2* |
| Chokecherry             | 65 $\pm$ 6  | 24 $\pm$ 3*  | 4.3 $\pm$ 0.5 | 1.6 $\pm$ 0.6* |
| Wild plum               | 70 $\pm$ 10 | 11 $\pm$ 6*  | 4.6 $\pm$ 0.8 | 1.3 $\pm$ 0.7* |
| Russian olive           | 43 $\pm$ 8  | 28 $\pm$ 18* | 4.8 $\pm$ 0.3 | 3.1 $\pm$ 0.5* |

\*Significantly different at  $\alpha = 0.05$ .

<sup>1/</sup>Survival after three years.

survival of all plants on the ungrazed sites after three years (43%), while wild plum was lowest of all plant species on the grazed sites (11%). Reductions in survival and height were expected on the grazed sites, largely because of browsing and trampling by cattle. Most transplanted trees and shrubs showed satisfactory survival and growth, especially when not grazed by livestock.

#### Shrub and Tree Seedling Densities

Trends of saskatoon serviceberry indicated higher, but not statistically significant, densities when livestock grazing was excluded (Fig. 1). Indications were that serviceberry densities were greater on the uncut tree stands for the first three years, but not significantly. No trends were observed between uncut and cut stands after three years.

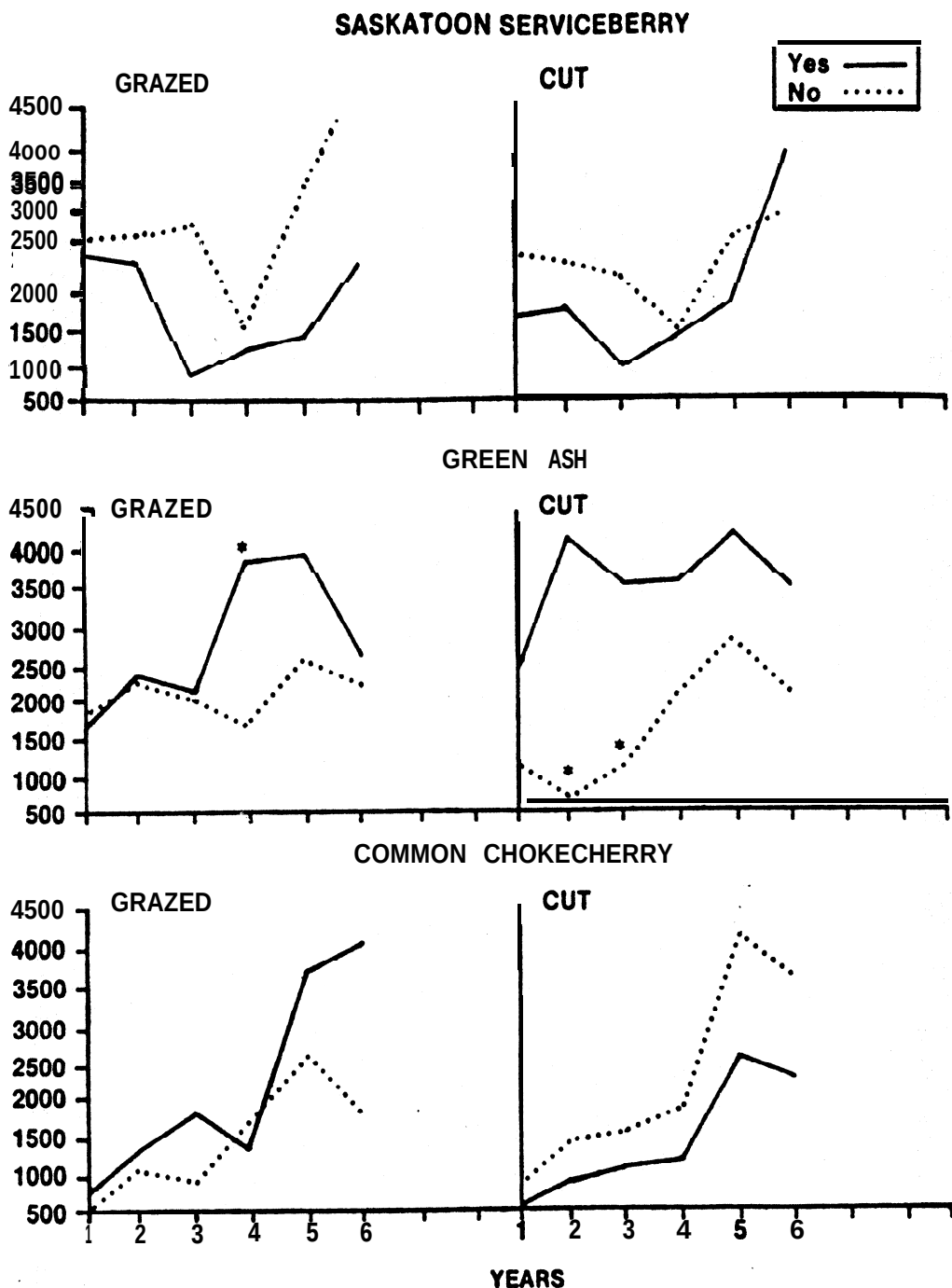


Figure 1. Response of woody plants (stems/ha) on treatments grazed (Yes), ungrazed (No), and 40% overstory trees cut-removed (Yes) and uncut trees (No) over a six-years period. \*Treatments are significantly different at  $\alpha < 0.04$ .

Green ash seedling densities were greater on the grazes site ( $P < 0.01$ ) during the fourth post-treatment year (Fig. 1), and the trend persisted during the fifth and sixth years. Most of the increase was due to first-year seedlings. Woodlands with approximately 40% of the overstory trees removed showed higher densities of green ash during the second and third years following treatment. However, higher trends are evident throughout the study period.

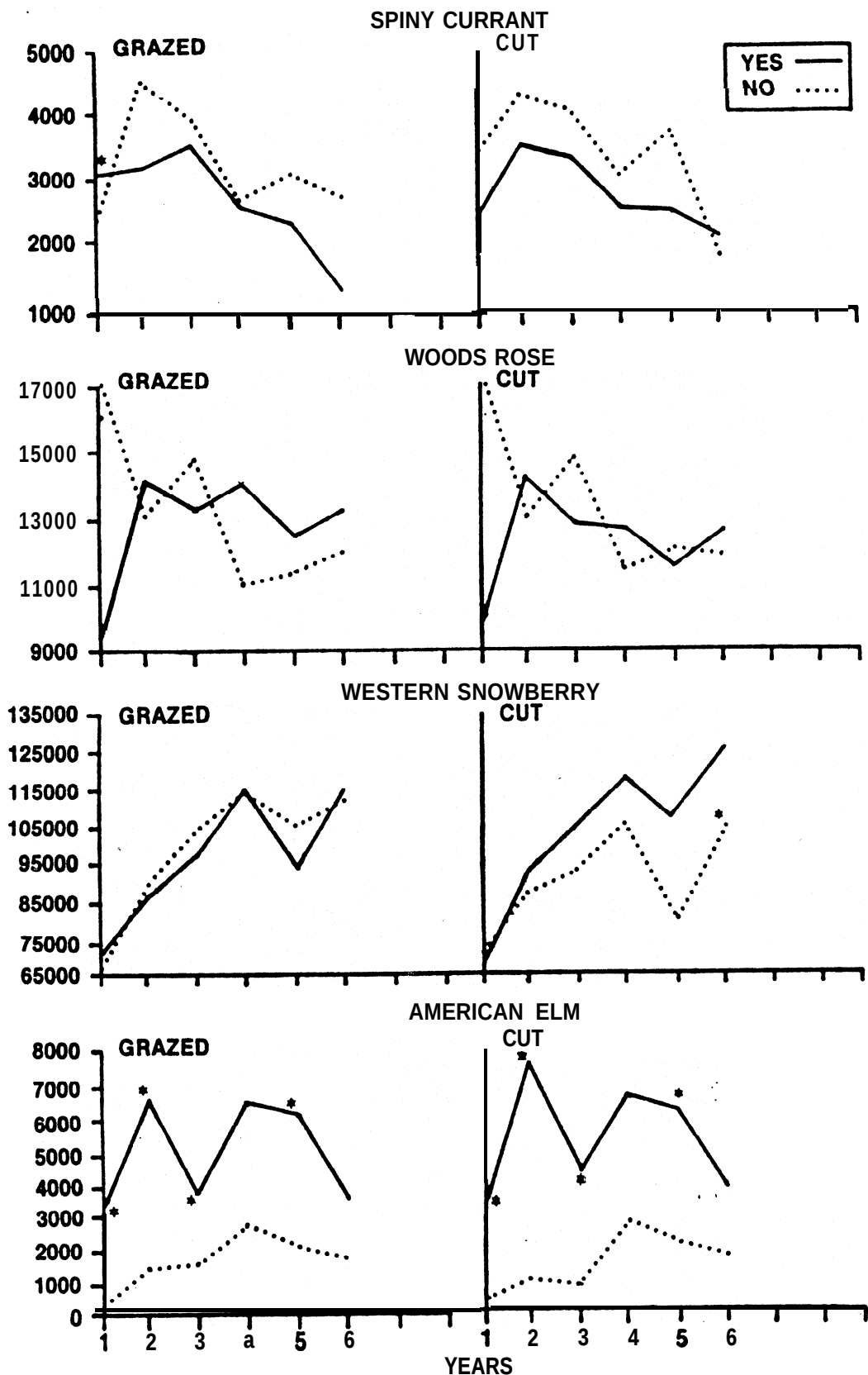


Figure 2. Response of woody plants (stemsha) on treatments grazed (Yes), ungrazed (No), and 40% overstory trees cut-removed (Yes) and uncut trees (No) over a six-year period. \*Treatments are significantly different at  $\alpha < 0.04$ .

Stem densities of common chokecherry showed irregular and no differences between grazed and ungrazed treatments (Fig. 1). However, chokecherry density trends were greater on the uncut stands throughout the six years, but this was not statistically significant.

Densities of spiny currant showed an increase ( $P < 0.04$ ) on grazed stands the first year after treatment (Fig. 2). However, trends were irregular thereafter with no significant differences. A biological trend of higher spiny currant densities was evident the first five years in woodlands that did not have trees removed, but there were no statistical differences.

Woods rose was highly variable and irregular in stem densities, with no trends on both the grazed and cut-tree stands (Fig. 2). The Largest response in density occurred the first post-treatment year for both treatments.

Trends were similar for western snowberry on grazed and ungrazed stands with no significant differences (Fig. 2). However, a reduction in overstory trees showed an increase in snowberry densities the sixth year after initial treatment.

Density of American elm was consistently greater on the grazed compared to the ungrazed sites the first, second, third, and fifth years (Fig. 2). Most American elm densities on both grazed and cut sites were yearly seedlings, and few survived to the second year ( $P < 0.01$ ). When 40% of the trees were removed, significantly higher densities of American elm occurred on the sites.

Standing Crop of Understory

Standing crop estimates on native woodlands are not available on the Great Plains. Estimates were generally greater on the ungrazed than on the grazed sites (Table 3). Standing crop for grass for the three years of record averaged 1104 kg/ha on the ungrazed sites and 702 kg/ha on the-grazed sites. Forbs showed a similar treatment response with an average of 117 kg/ha and 73 kg/ha

Table 3. Standing crop (kg/ ha  $\pm$  standard error) of herbage during late August – early September on grazed-ungrazed and thinned-unthinned tree plots.

| Category            | Post-treatment<br>year | Treatment      |               |                |                |
|---------------------|------------------------|----------------|---------------|----------------|----------------|
|                     |                        | Ungrazed       | Grazed        | Thinned        | Unthinncd      |
| Grass <sup>1/</sup> | 4                      | 1352 $\pm$ 406 | 818 $\pm$ 185 | 1266 $\pm$ 431 | 904 $\pm$ 170  |
|                     | 5                      | 1058 $\pm$ 113 | 518 $\pm$ 93* | 917 $\pm$ 152  | 659 $\pm$ 144  |
|                     | 6                      | 901 $\pm$ 110  | 770 $\pm$ 147 | 904 $\pm$ 97   | 767 $\pm$ 155  |
| Forbs               | 4                      | 135 $\pm$ 58   | 86 $\pm$ 29   | 112 $\pm$ 54   | 109 $\pm$ 38   |
|                     | 5                      | 95 $\pm$ 22    | 42 $\pm$ 7*   | 72 $\pm$ 19    | 65 $\pm$ 22    |
|                     | 6                      | 121 $\pm$ 33   | 90 $\pm$ 25   | 118 $\pm$ 24   | 92 $\pm$ 34    |
| Total               | 4                      | 1487 $\pm$ 387 | 904 $\pm$ 199 | 1378 $\pm$ 423 | 1013 $\pm$ 178 |
|                     | 5                      | 1153 $\pm$ 100 | 560 $\pm$ 99* | 989 $\pm$ 156  | 724 $\pm$ 154  |
|                     | 6                      | 1022 $\pm$ 86  | 860 $\pm$ 156 | 1022 $\pm$ 103 | 859 $\pm$ 145  |

\*Statistically significant at  $\alpha = 0.10$

<sup>1/</sup>Includes sedges

for ungrazed and grazed sites, respectively. Average total standing crop for both categories over three years was 1221 kg/ha (ungrazed) and 775 kg/ha (grazed).

A 40% removal of the overstory trees resulted in no significant increases in standing crop values for grasses and forbs (Table 3). Grasses averaged 1029 kg/ha on the cut and 777 kg/ha on the uncut tree stands over a three-year period and were variable. Standing crop of forbs averaged 101 kg/ha (cut) and 89 kg/ha (uncut). Total standing crop averaged 1130 kg/ha and 865 kg/ha on cut and uncut tree stands, respectively.

## DISCUSSION

Regeneration of native woodlands on the northern Great Plains is a slow process. However, removal of the overstory trees that were in the late stages of decadence resulted in sprouting from the stumps. Cattle browsing stimulated additional sprouts on stumps as compared to stumps protected from grazing. Some sprouts were heavily used, but most survived at the end of five years with an average height of the tallest sprout of 9 dm. However, a height of 16-18 dm, which is beyond the grazing height of livestock, may be required to rejuvenate the tree. When livestock were excluded, 5 % of the original stand died by the end of the five years; however, no tree mortality occurred when the stand was cut and grazing was excluded. Removal of trees, in conjunction with no or light grazing by livestock during the first 2-3 years, would allow for stands of overstory tree species in woodlands to rejuvenate themselves.

Planting of shrubs and trees may be used to reestablish viable stands of woodlands, but the cost may be prohibitive. Survival of containerized stock was low when grazed by cattle. However, green ash, Rocky Mountain juniper, and bur oak showed some promise. Reductions in survival of unfenced seedlings were expected and were largely due to browsing and trampling by livestock. Total exclusion of livestock provided favorable results in survival of containerized plantings. A reduction in livestock use or individual protection of plantings may be alternatives to promote and enhance growth of woodland species.

Regeneration of shrub and tree seedlings by livestock exclusion and tree thinning treatments over a five-year period was slow for some species, while others did not show solid indications of increases in stem density. Each species responded differently to livestock grazing and cutting of overstory trees. Some shrubs increased with additional sunlight. No one treatment showed beneficial results for all plant species. Individual shrub and tree seedling management objectives would be required to maintain or increase stem density. American elm and green ash seedlings generally increased in density when stands were grazed and overstory trees removed; however, most seedlings died yearly (> 99%). This loss was attributed to competition of dense grass stands with high levels of potential productivity and to browsing by cattle (Boldt et al. 1978).

Shrub utilization by cattle is common and generally increases with increased maturity of herbaceous vegetation (Roath and Krueger 1982, Holechek et al. 1982, Uresk and Lowrey 1984, Uresk and Paintner 1985). However, light or moderate use of many shrubs by livestock results in greater vegetative growth than no use (Garrison 1953, Ellison 1960). Knowledge of seasonal shrub use

by livestock through dietary analyses will enable managers to adjust stocking rates of livestock at critical times periods to maintain or increase shrub stands in woodlands on the northern Great Plains.

As a basis for management decisions, old decaying woodlands must be recognized and classified as to their potential for conversion to healthy, productive stands. Dense, productive woodlands provide food and cover for wildlife, trap winter snows, and provide shading areas for livestock (Uresk 1982, MacCracken et al. 1983, Kauffman and Krueger 1984). Woodlands that show signs of decadence and slow regeneration can be improved by the cultural practices discussed here, but this may be cost-prohibitive. Severely decadent woodlands with few or no trees and limited understory woody plants may be managed for forage (grass and forb) and livestock production.

In general, there are good indications that partial felling and removal of decadent trees will stimulate sprout regeneration of green ash and American elm after five years. Light or no grazing by livestock during the first 2-3 years would allow tree sprouts to grow and maintain stands of overstory trees. In addition, some shrub stands can also be improved and maintained. Shrub and tree seedlings can be successfully transplanted and, when grazing is excluded, survival of most trees and shrubs improves. Densities of some shrubs showed increases over a six-year period with both grazing and cutting treatments, but this response varied for individual species. Only one woody species out of seven showed a significantly different response to grazed and ungrazed treatments. Removal of tree stems (40%) resulted in two-species out of seven showing a change due to treatment effects. Understory woody species should be managed on an individual species basis depending upon the manager's objectives. This may involve reduced grazing, removal of overstory trees, or both. However, the treatment response is slow and is nonexistent for some plants.

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