Effects of Livestock Grazing and Cultural Treatments on Regeneration of Green Ash Woodlands on the Northern Great Plains: An Update

Daniel W. Uresk, USDA Forest Service, Rapid City, SD. 57701.

Daryl E. Mergen, Ecological Delineations, Inc., Colorado Springs, CO 80905

Abstract

Many green ash woodlands (*Fraxinus pennsylvanica*) have become decadent with broken stems and limited regeneration of both trees and shrubs on the northern Great Plains. The purpose of this study was to determine the response of woodland regeneration of shrubs, trees and planting woody species over 25 post-treatment years (1) to livestock grazing with thinning low vigor trees, (40% reduction) in woodlands with transplanting woody plants, (2) livestock grazing with un-thinned woodlands-no transplanting of woody plants, (3) no livestock grazing with thinning low vigor trees, (40% reduction) in woodlands with transplanting woody plants, and (4) no livestock grazing with un-thinned woodlands-no transplanting of woody plants. Initial treatment response for trees and shrubs occurred during the first 6 years of post-treatment. After 25 years of post-treatment, trees and shrubs were not different between livestock grazing and no grazing treatments. American elm (*Ulmus americana*) decreased in stem density and may have been influenced by disease. Stem density of snowberry (*Symphoricarpos occidentalis*) decreased in the unthinned treatment. Common chokecherry (*Prunus virginiana*) stem densities remained relatively constant over 25 years of post-treatments. Planted shrub and tree species had greater than 50% survival in ungrazed versus grazed treatments. Survival of bur oak (*Quercus macrocarpa*), Rocky Mountain juniper (*Juniperus scopulorum*) and American plum (*Prunus americana*) was greater when livestock grazing was excluded. Herbaceous standing crop of the grasses, forbs, and total was variable throughout all years among treatments.

Key Words: green ash, decadent trees, thinning, herbage, prairie, regeneration, plantings, livestock grazing.

Introduction

Green ash (*Fraxinus pennsylvanica*), riparian-like woodlands, are generally confined to draws or ravines that have ephemeral streams on the Northern Great Plains. They occupy less than 1% of the land on the plains (Jakes and Smith 1982). However, many green ash woodlands have become decadent with low vigor, little or no regeneration, and dying or partially dead trees. These woodland systems have poor reproduction of trees, shrubs, and many are overgrazed being replaced by grasses and forbs (Severson and Boldt 1978, Boldt et al. 1978, Lesica and Marlow 2013). Although restoration of these decadent woodlands is a slow process, some shrubs and green ash trees will respond to cultural treatments by reversing decadence (Uresk and Boldt 1986, Lesica 2009). Small in area, green ash woodlands are very important for livestock and wildlife providing food and cover, including nesting cover, for birds during summer months and protection during the winter (Severson and Boldt 1978, Bjugstad and Sorg 1985, MacCraken and Uresk 1984, Butler and Goetz 1984, Hodorff et al. 1988, Rumble and Gobeille 1998, Lesica and Marlow 2013).

Livestock grazing can result in decreased plant vigor and alteration of plant communities and species composition (Garrison 1953, Willard and McKell 1978, Ellison 1960), however, it may be just one of many factors that impact prairie woodland regeneration. Bolt et al. (1978) and Severson and Boldt (1978) reported many shrub-tree stands are degenerating because they are near the end of their lifespan. Older trees may also be more susceptible to disease, insects, and grazing (Lesica and Marlow 2013). The construction of stock ponds, roads, climate, geology, soils, plant succession, and wildfire suppression may be other factors that influence the long-term changes in prairie woodlands.

The objectives of this study were to determine the vegetation response of regeneration to four cultural treatments for trees, shrubs, and herbaceous standing crop on the northern Great Plains over 25 post-treatment years (1) to livestock grazing with thinning low vigor trees (40% reduction) in woodlands with transplanting woody plants, (2) livestock grazing with un-thinned woodlands-no transplanting of woody plants, (3) no livestock grazing with thinning low vigor trees, (40% reduction) in woodlands with transplanting woody plants, and (4) no livestock grazing with un-thinned woodlands-no transplanting of woody plants (Uresk and Boldt, 1986).

Study Area

This study was located on the Little Missouri National Grasslands, Dakota Prairie Grasslands, in western North Dakota. The green ash woodlands were selected in the upper reaches of Magpie Creek Drainage 41.8 km (26 miles) north of Belfield. Climate is cool-temperate, semi-arid with variable precipitation and temperatures. Average precipitation from 1981-2010, at Grassy Butte, ND (Grassy Butte 2ENE), approximately 12.9 km (8 miles) north of the study area was 41cm (16.2 inches) (Climod 2 2016). Average growing season temperature from April to September was 15.2^{0}C (59.3^{0}F); winter temperature (October-March) averaged -3.1^{0}C (26.4^{0}F). Dominant trees within the selected woodlands were green ash and American elm (*Ulmus americana*). The shrub understory included western snowberry (*Symphoricarpos occidentalis*), Wood's rose (*Rosa woodsii*), spiny currant (*Ribes setosum*), Saskatoon serviceberry (*Amelanchier alnifolia*), silver buffaloberry (*Shepherdia americana*), common chokecherry (*Prunus virginiana*), American plum (*Prunus americana*), hawthorn (*Crataegus* spp.), and raspberry (Rubus spp.). Common grass and grass-like species included Kentucky bluegrass (*Poa pratenensis*) and sedges (*Carex* spp.) (Boldt 1978). Plant nomenclature followed USDA-NRCS (2016).

We selected green ash study areas located in two pastures grazed by cattle in a three pasture allotment under a deferred rotation grazing system. Stocking rate was 1.07 AUMs/ha (animal unit months) from May 15 to October 30. This area had been grazed season long as a single pasture prior to establishing a three pasture deferred rotation grazing system. The selected pastures were in the deferred grazing system two years before initiation of the study (Uresk and Boldt 1986).

Methods

We selected twelve sites, 0.08 ha, for sampling within several green ash draws (Boldt et al. 1978). The study included four treatments (1) livestock grazing with thinning low vigor trees (40% reduction) in woodlands with transplanting woody plants, (2) livestock grazing with un-thinned woodlands-no transplanting of woody plants, (3) no livestock grazing with thinning low vigor trees, (40% reduction) in woodlands with transplanting woody plants, and (4) no livestock grazing with un-thinned woodlands-no transplanting of woody plants. Herbaceous standing crop of grasses (including sedges), forbs, and total was harvested within the four treatments. The four treatment combinations were randomly administered among the 12 sample sites with 3 replications per treatment. Fences to exclude cattle were constructed by the fall of 1975.

Pretreatment and post-treatment measurements were collected during the end of the growing season each year.

Pretreatment measurements were collected in 1975 and post-treatment measurements were collected for shrubs, small trees on all sites for six subsequent years (1976-81) and in 2001, 26 years after initial installment of treatments. Small trees (less than 2.5 cm Diameter Breast Height (DBH)) and shrubs stem and heights were measured by species on five randomly located 15.3 by 1.2 meter belt transects (18.4 m^2) within each sample site.

Sites selected for tree removal were selectively cut to 40% of total tree stems to open the canopy and stimulate sprouting in 1975 (Boldt et al. 1978). Decadent trees with low vigor (rotten, broken, and poorest of the growing stock as described by Boldt et al. 1978) were cut and removed from plots. Tree species composition on each of the 12 sites was determined before and after tree removal. Decadent trees from each cut site were randomly selected and number of sprouts per stump and height of sprouts each year were measured.

We planted containerized tree and shrub seedlings on the thinned tree sites in spring of 1977 (second post-treatment year). Green ash, Rocky Mountain juniper (*Juniperus scopulorum*), bur oak (*Quercus macrocarpa*), common chokecherry, American plum, and Russian olive (*Eleagnus angustifolia*) were planted. Twenty-four containerized seedlings of each species were planted in each of the six partially cut woodland sites on herbicide-treated (2, 2 dichloropropionic acid) spots. All species and containerized pots were randomly distributed throughout a systematic lattice pattern with 2-3 meter spacing.

Understory herbaceous biomass estimates were obtained by clipping 20 (31-cm x 61 cm) quadrats in 1979-1981 and 20 (50 x 50 cm) quadrats in 2001. Quadrats were clipped to ground level at all 12 sites in late August. Grasses (sedges included) and forbs were separated, placed in paper bags, oven-dried for 48 hours at 60^0C and weighed to the nearest 0.1 g. Weights for grazed and ungrazed herbage were expressed as kg•ha^{-1}.

Shrub stems and height measurements by species were averaged by site for statistical analyses. Analysis of covariance, using 1975 year's data as the covariate, was used for mean adjustment for each of the post treatment years for each species (SPSS 2003). Six years of posttreatment adjusted means were averaged between two grazing treatments and two thinned treatments. T-tests were used to evaluate differences between treatments at $p \leq 0.10$. The 25^{th} year adjusted mean of post-treatment effects of two grazing and two thinned treatments were evaluated by T-tests based on means of six sites by treatment.

We used Chi-square analysis (2 x 2) 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 and two thinned conditions for the number of sprouts per stump, height of clump sprouts, heights of planted trees and shrubs, and herbaceous plant biomass. All significant levels were set at $p \leq 0.10$ unless stated otherwise.

Results

Stand Composition and Partial Cutting

Measurements of pre-treatment overstory consisted of 60% green ash (286 ± 37 trees ha^{-1} ± SE), 38% American elm (185 ± 67 trees ha^{-1}) and 2% other tree species (10 ± 5 trees ha^{-1}) (Uresk and Boldt 1986). Forty percent of the pre-treatment overstory tree stems were determined to be decadent and were cut. Twenty-five years post-treatment overstory consisted of 94% green ash (900 ± 158 trees ha^{-1}), 5% American elm (54 ± 13 trees ha^{-1}) and 1% box-elder (*Acer negundo*) for cut stands. Uncut stands had 97% green ash (894 ± 140 trees ha^{-1}) and 3% American elm (27 ± 9 trees ha^{-1}). Dead trees were measured in 2001(25 years post-treatment) and 78% and 55% of the dead trees were American elm for cut and uncut sites, respectively.

Tree Stump Sprouts and Height

Sixty percent of the stumps on the grazed plots produced sprouts and 96% on the ungrazed sites after 25 years. Most stumps produced sprouts the year following tree removal (Table 1). The mean number of live sprouts per stump after 25 years of post-treatment were 2 stems on grazed and 3 stems on ungrazed sites. Average heights of clumps on grazed sites were 21 dm compared to ungrazed sites with 41 dm. After 25 years post-treatment, the tallest live sprout was 41 dm shorter on the grazed sites compared to ungrazed sites (Table 1). All measured plant characteristics (Table 1) indicated a greater percentage or greater height (nearly 2 times) on ungrazed treatment compared to grazed treatment after 25 years.

Survival and Heights of Plantings

Survival was significantly greater for all planted shrubs and trees on ungrazed sites compared to grazed sites, except for Russian olive 25 years post-treatment (Table 2). Percent survival after 25 years post-treatment ranged from a low of 4% for Russian olive to a high of 51% for chokecherry on ungrazed sites. Bur oak and Rocky Mountain juniper had 35% and 31% survival, respectively. Wild plum and green ash had survival rates of 17% and 8%, correspondingly after 25 years of post-treatment on ungrazed sites. Grazed sites exhibited lower survival rates after 25 years, ranging from no survival with bur oak to a high of 19% for chokecherry. Russian olive and wild plum on grazed sites had 3% survival; green ash and Rocky Mountain juniper had 1% survival.

Stem heights were significantly taller after 25 years post-treatment on ungrazed sites compared to grazed sites for Rocky Mountain juniper, bur oak, chokecherry and Russian olive (Table 2). Russian olive (46 dm) had the greatest stem height on ungrazed sites followed by Rocky Mountain juniper (23 dm), chokecherry (16 dm), 11 dm for both green ash and bur oak, and 6 dm for wild plum. On grazed sites, stem heights were greatest for chokecherry, Russian olive and green ash, each approximately 7-8

Table 1. Tree stumps with live sprouts from one year post treatment to 25 years on grazed and ungrazed treatments (mean ± standard error) north of Belfield ND.

Category	Post-treatment year	Treatment Ungrazed[1]	Grazed
% stumps with sprouts	1-1976	98 ± 2	100 ± 0
	3-1979	95 ± 2	95 ± 3
	5-1980	93 ± 4	87 ± 7
	25-2001	96 ± 3	60 ± 28
Sprouts/stump	3-1979	14 ± 1	17 ± 2
	5-1980	13 ± 1	16 ± 1*
	25-2001	3 ± <1	2 ± 1
Sprout height/stump (dm)	3-1979	11 ± 1	6 ± 2*
	5-1980	16 ± 1	6 ± 2*
	25-2001	41 ± 2	21 ± 11*
Tallest sprout/stump (dm)	3-1979	16 ± 1	9 ± 2*
	5-1980	21 ± 1	9 ± 3*
	25-2001	79 ± 4	38 ± 19*

[1] n = 6 sites/ treatment.

* Significant at $p < 0.10$

Table 2. Survival (%) and height (dm) of planted trees and shrubs on ungrazed and grazed treatments after 25 years of post- planting (mean ± standard error) north of Belfield ND.

Species	Post-planting year	Survival Ungrazed	Survival Grazed	Heights (dm) Ungrazed	Heights (dm) Grazed
Green Ash	3[1]	72 ± 7	38 ± 5*	4.2 ± 0.3	3.0 ± 0.3*
	25	8 ± <1	1 ± <1*	11.4 ± 6.9	7.0 ± 7.0
Rocky Mountain Juniper	5	88 ± 3	61 ± 6*	4.4 ± 0.5	3.9 ± 0.2
	25	31 ± <1	1 ± <1*	23.4 ± 1.2	1.8 ± 1.8*
Bur oak	5	82 ± 5	44 ± 6*	2.8 ± 0.4	1.2 ± 0.2*
	25	35 ± <1	0 ± 0*	11.2 ± 3.6	0.0 ± 0.0*
Chokecherry	5	65 ± <1	24 ± 3*	4.3 ± 0.5	1.6 ± 0.6*
	25	51 ± 4	19 ± <1*	5.5 ± 2.1	7.6 ± 3.8*
Wild plum	5	70 ± 10	11 ± 6*	4.6 ± 0.8	1.3 ± 0.7*
	25	17 ± <1	3 ± <1*	6.3 ± 3.7	2.3 ± 2.3
Russian olive	5	43 ± 8	28 ± 18*	4.8 ± 0.3	3.1 ± 0.5*
	25	4 ± <1	3 ± <1	45.6 ± 8.6	7.1 ± 7.1*

[1] n = 6 sites/ treatment. (post years 3-1978, 5-1980 to 25-2001).

* Significant at p < 0.10

dm tall. Wild plum and Rocky Mountain juniper both averaged about 2 dm height after 25 years post-treatment on grazed sites. All measured plant characteristics (Table 2) indicated a greater percentage survival or greater height (nearly 1.6-13 times) on ungrazed treatment compared to grazed treatment after 25 years.

Shrub and Tree Sprout Densities

Six year post-treatment averages for ungrazed compared to grazed stem densities showed significant differences for American elm, chokecherry and serviceberry (Table 3). American elm stem densities were greater than 200% on the grazed areas. Chokecherry average increase over the six years was 39% higher on the grazed sites while serviceberry showed an increase of 61% on the ungrazed treatment. After 25 years there were no significant differences between ungrazed and grazed treatments for all seven species. Details of the first 6 years of post-treatment effects by year for ungrazed, grazed, thinned and unthinned treatments are presented by Uresk and Boldt (1986). Snowberry and the spined shrubs (rose and current) increased over the past 25 years on grazed treatment compared to ungrazed. Green ash also had more stems per hectare with grazing compared to ungrazed.

Unthinned overstory treatments for stem densities of woody plants averaged over six year post-treatments were significantly less for green ash, American elm and snowberry (Table 3). Stem densities were significantly greater on the unthinned treatment for chokecherry and spiny current. Green ash densities were greater on the thinned overstory tree sites by 130% compared to the unthinned treatment. American elm increased over 300% on the thinned treatment as related to the unthinned sites. Chokecherry increased 42% on the unthinned treatment. Spiny current showed 16% increase on the unthinned areas while, snowberry exhibited a 14% decrease. After 25 years, only snowberry showed significant stem density increase with 43% on the thinned overstory treatment. Overall, (Table 3), although not significantly greater, the unthinned trees (green ash and American elm) may have done better after 25 years compared to the thinned treatments, while all shrubs increased with the thinned treatments.

Table 3. Response of woody plants within green ash woodlands on ungrazed-grazed and thinned-unthinned post-treatments with means of the first six years compared to the 25th year (stems/ha ± standard error) north of Belfield ND. Means adjusted by covariance

Category	Post-treatment year	Ungrazed	Grazed	Thinned	Unthinned
Green Ash	1-6[1]	2224 ± 164	2765 ± 344	3487 ± 214	1502 ± 312*
	25[2]	807 ± 648	3220 ± 1660	1600 ± 571	2427 ± 1687
American Elm	1-6	1567 ± 266	5127 ± 623*	5435 ± 565	1257 ± 458*
	25	460 ± 269	62 ± 62	198 ± 222	324 ± 224
Chokecherry	1-6	1582 ± 376	2199 ± 524*	1560 ± 367	2222 ± 502*
	25	5780 ± 6411	10396 ± 5194	14754 ± 3677	1421 ± 7359
Serviceberry	1-6	2609 ± 379	1620 ± 195*	1880 ± 327	2348 ± 212
	25	5268 ± 1955	4799 ± 2182	5127 ± 2092	4941 ± 2066
Woods Rose	1-6	13497 ± 936	12938 ± 689	12702 ± 564	13733 ± 740
	25	5178 ± 1969	5785 ± 2281	7771 ± 2322	3192 ± 1428
Spiny Currant	1-6	3311 ± 316	2862 ± 315	2842 ± 227	3295 ± 331*
	25	273 ± 444	2808 ± 2033	2542 ± 1976	1560 ± 407
Snowberry	1-6	98802 ± 6995	96611 ± 6977	103941 ± 8352	91472 ± 6170*
	25	300351 ± 44515	367092 ± 46872	393076 ± 24419	274368 ± 39106*

[1] mean of 6 years post treatment (1976-1981), n = 6 years.

[2] mean of 25th year (2001) post treatment. n = 6 sites

* Significant at $p < 0.10$.

Herbaceous Standing Crop

Standing crop estimates were significantly greater ($p = 0.03$) on the ungrazed than on the grazed treatment over all post-treatment years with a 36% difference in total herbage (Table 4). During the fifth year post-treatment, grasses, forbs and total standing crop of all vegetation were significantly different between treatments. Average total standing crop for all post-treatment years was 1596 kg•ha^{-1} (ungrazed) and 1173 kg•ha^{-1} (grazed). Grasses yielded 1353 kg•ha^{-1} on the ungrazed and 1016 kg•ha^{-1} on the grazed treatments. Standing crop of forbs was low with 243kg•ha^{-1} and 158 kg•ha^{-1} on ungrazed and grazed treatments, respectively. Precipitation for 2001 (25 year post treatment) was greater than the long-term mean while post treatment years 4-6 (1979-1981) were less than the long-term average.

Removal of 40% decadent overstory trees resulted in a significant increased total standing crop of understory vegetation ($p = 0.07$) when considering all post-treatment years with a 16% increase compared to the uncut treatment (Table 4). There were no treatment differences within individual post-years but standing crop was variable between and among years. All other years (years 4,6, and 25) were variable with no treatment differences. Average total standing crop for all post-treatment years was 1487 kg•ha^{-1} and 1282 kg•ha^{-1} on thinned and unthinned treatments, respectively. Grasses yielded 1291 kg•ha^{-1} on thinned and 1078 kg•ha^{-1} on unthinned treatments. Average yield of forbs was 196 kg•ha^{-1} and 205 kg•ha^{-1} for all post-treatment years on thinned and unthinned treatments, correspondingly.

Table 4. Standing crop within green ash woodlands during late August-early September on ungrazed-grazed and thinned-treatments after 4 to 25 years (kg/ha ± standard error) north of Belfield ND.

Category	Post-treatment year	Ungrazed[1]	Grazed	Thinned	Unthinned
Grass	4-1979	1352 ± 406	818 ± 185	1266 ± 341	904 ± 170
	5-1980	1058 ± 113	518 ± 93*	917 ± 152	659 ± 144
	6-1981	901 ± 110	770 ± 147	904 ± 97	767 ± 155
	25-2001	2101 ± 538	1956 ± 383	2077 ± 471	1980 ± 464
Forb	4-1979	135 ± 58	86 ± 29	112 ± 54	109 ± 38
	5-1980	95 ± 22	42 ± 7*	72 ± 19	65 ± 22
	6-1981	121 ± 33	90 ± 25	118 ± 24	92 ± 34
	25-2001	621 ± 138	413 ± 50	482 ± 119	552 ± 106
Total	4-1979	1487 ± 387	904 ± 199	1378 ± 423	1013 ± 178
	5-1980	1153 ± 100	560 ± 99*	989 ± 156	724 ± 154
	6-1981	1022 ± 86	860 ± 156	1022 ± 103	859 ± 145
	25-2001	2723 ± 508	2369 ± 367	2559 ± 403	2533 ± 493

[1] n = 6 sites/treatment.
* Significant at $p < 0.10$.

Discussion

Green ash woodlands on the Northern Great Plains have existed for many years and have been documented along the Missouri River and its tributaries since the 1870’s and 1880’s (Rumble et al. 1998, Severson and Sieg 2006). These woodlands were common prior to early European settlement but have been heavily modified by cultivation, urbanization and livestock grazing. Many of the woodlands have been altered by variations of livestock management with many woodlands becoming decadent with little regeneration while others have been replaced by grasses and forbs (Severson and Boldt 1978, Boldt et al. 1978, Uresk and Boldt 1986, Lesica and Marlow 2013). Regeneration of native green ash woodlands to a desired successional seral stage as defined by resource managers may be a long-term process. Recruitment of green ash seedlings by seed from mature trees in wooded draw systems is not common. Our observations show that seeds sprout, but competition by grass and grazing eliminates most seedlings. Lesica (2009) reported similar results with seed sprouting. A few ash seedlings do survive within the cover of snowberry (Uresk, personal observations) or in and around adjacent felled trees where grazing and grass competition are reduced.

Cutting and removal of decadent overstory trees resulted in sprouting from the stumps. Protection from grazing was beneficial for tree sprouts at the 5 year post-treatment and after exclusion from grazing for 25 years, the number of stumps with sprouts remained constant. Under a three pasture deferred grazing system, 36% of the stumps had no sprouts. After 25 years, heights of tallest sprout stems on ungrazed treatments were 79 dm, approximately twice as tall as on the grazed treatment. Lesica (2009) reported stem heights from stumps after less than 20 years at 70 dm in eastern Montana. Protection from grazing of sprouts from cut stumps for 5 years is recommended until the terminal stems reach a height of 16 dm. Green ash stems > 16 dm will become mature trees. Protection from grazing for 5 years will meet this requirement with green ash and other trees.

For example, Smith et al. (1972) reported average heights of stems 15 dm was required to minimize damage to aspen terminals from being browsed.

Survival and growth of planted shrubs and trees were variable among species. Rocky Mountain Juniper, bur oak and chokecherry had very good survival from plantings after 25 years with no grazing, but much lower with livestock grazing. Protection of shrub and tree plantings from grazing enhanced survival. However, reduction in livestock stocking rates or grazing pastures early during the growing season before cattle utilize shrubs, tree sprouts and seedlings in the woodlands would be beneficial (Roath and Krueger 1982, Holechek et al.1982, Uresk and Paintner 1985, Lesica and Marlow 2013). Plantings may be a cost prohibitive method to replace decadent stands on the northern Great Plains. However survival could be enhanced by excluding livestock grazing.

Regeneration of shrubs in green ash woodlands is a slow process, but some shrubs responded positively with cultural treatments during the first six years of post-treatment (Uresk and Boldt 1986). Indications are that most shrub responses to treatment did not change after six years. Shrubs and trees that increased stem density during six year post-treatment period with grazing in a three pasture deferred grazing system were American elm, chokecherry, and serviceberry, while other shrubs were static at the end of six years. The unthinned cultural treatment was beneficial, averaged over the six year period for chokecherry and spiny current while snowberry decreased. Thinning overstory decadent trees increased stem density of green ash and American elm. However, at 25 years post-treatment, snowberry stem density decreased in the unthinned treatment. The decrease can be attributed to the increased tree density and canopy cover providing shade and competition with increased density of shrubs. Similar results were reported by Lesica (2009) and Lesica and Marlow (2013) in eastern Montana.

American elm's decrease could be somewhat influenced by infections of Dutch elm disease or Dothiorella wilt during the past 20 years of the study as indicated with additional dead mature stems and many dead sprouts (Stack and Laut 1986, Krupinsky and James 1986). However we did not investigate disease during this study, but a greater number of American elm trees had died compared to green ash between 1981 and 2001.

The emerald ash borer (*Agrilus planipennis*), a native of China, was possibly introduced into eastern United States through wood packing material for shipping items around 1990's and has spread to over 20 states and two Canadian provinces (Liang and Fei 2014). However, it has invaded areas with a milder climate and a longer growing season of 150 days with annual precipitation of 51cm-102cm (20-40 inches) (Lesica and Marlow 2013). Many areas in the Dakotas, and Wyoming have shorter growing seasons and less precipitation. Our study area had a growing season of 112 days and 41cm (16 inches) of precipitation with harsh winters (Climod 2 2016). Climate suitability prediction for models by Liang and Fei (2014) for the emerald ash borer, indicate green ash woodlands commonly confined to draws on the northern Great Plains prairie region, generally indicate a range from unsuitable to low suitability habitat for the ash borer. The emerald ash borer is not expected to tolerate these harsher and drier conditions.

Many green ash stands are not regenerating because of livestock and wildlife browsing sprouts and seedlings. Grazing promotes sod forming grasses that out-compete young seedlings (Uresk and Boldt 1986, Lesica and Marlow 2013). Excluding livestock by fencing ash woodlands in need of regeneration is expensive and alternative grazing systems should be considered. Green ash woodlands in mid to late seral stages were in pastures considered in excellent condition. The uplands were not heavily used by cattle resulting in limited use within the green ash draws. A successful method for regeneration of aspen stands is to reduce livestock and wildlife grazing by hinging (cutting tree stems) (Kota and Bartos 2010). Hinging consists of cutting tree stems approximately 1m or lower above ground but maintaining stem connection to the stump. Although not tested in green ash woodlands, hinging decadent ash trees may be feasible to limit livestock grazing in these woodlands instead of fencing to promote regeneration of ash seedlings, sprouts and increased shrubs densities. Other regeneration methods are presented by Lesica and Marlow (2013).

Literature Cited

Bjugstad, A.J. and D.F. Sorg. 1985. The value of wooded draws on the Northern High Plains for hunting, furs, and woodcutting. Pp 5-9. in D.L. Noble and R.R. Winokur, eds. Wooded draws: characteristics and values for the northern Great Plains. Symposium Proceedings. 1984 June 12-13; Rapid City, SD. Great Plains Agricultural Council. Pub. No. 111. Rapid City, SD: South Dakota School of Mines and Technology.

Boldt, C. E., D. W. Uresk and K. Severson. 1978. Riparian woodlands in jeopardy on Northern High Plains. Pp. 184-189. in R. R. Johnson and J. F. McCormick, eds. Strategies for protection and management of floodplain wetlands and other riparian ecosystems. Symposium Proceedings Dec. 11-13, Calloway Gardens, GA. USDA, Forest Service. General Technical Report. WO-12.

Butler, J. and H. Goetz. 1984. Influence of livestock on the composition and structure of green ash communities in the Northern Great Plains. in D. L. Noble and R. P. Winokur eds.. Wooded draws: characteristics and values for the Northern Great Plains. Rapid City, SD, USA: South Dakota School of Mines and Technology, p. 44-49.

Climod 2. 2016. Northeast RCC website. Available at: http://climodtest.nrcc.cornell.edu/. Monthly climate normals (1981-2010) Watford City 14S, ND. [Cited 1 November 2016].

Ellison, L. 1960. Influence of grazing on plant succession on rangelands. Botanical Review. 26: 1-78.

Garrison, G.A. 1953. Effects of clipping on some rangeland shrubs. Journal. Range Management. 6:309-317.

Hodorff, R.A., C.H. Sieg and R.L. Linder. 1988. Wildlife responses to stand structure of deciduous woodlands. Journal Wildlife. Management. 52:667-673.

Holechek, J.L., M. Vavra, J. Skovlin and W.C. Krueger. 1982. Cattle diets in the Blue Mountains of Oregon II. Forests. Journal Range Management 35:239-242.

Jakes, P. J., and W. B. Smith. 1982. A second look at North Dakota's timber land. U.S. Department Agriculture Forest Service, North Central Forest Experiment Station. Bulletin. NC-58.

Kota, A.M. and D.L. Bartos. 2010. Evaluation of techniques to protect aspen suckers from ungulate browsing in the Black Hills. Western Journal Applied Forestry. 25:161-168.

Krupinsky, J.M. and R. L. James. 1986. Dothiorella wilt of elm. in J.W. Riffle, G.W. Peterson, Technical Coordinators. Diseases of trees in the Great Plains. Gen. Tech. Rep. RM-129. Fort Collins, CO. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. 149p.

Lesica, P. 2009. Restoring green ash regeneration to declining hardwood draws. Final Report. Bureau of Land Management, Miles City, MT. 22 pp.

Lesica, P. and C. Marlow. 2013. Green ash woodlands: A review. Montana State University.

Liang, L. and S. Fei. 2014. Divergence of the potential invasion range of emerald ash borer and its host distribution in North America under climate change. Climate Change. 122:735-746.

MacCraken, J.G. and D.W. Uresk. 1984. Big game habitat use in southeastern Montana. Prairie Naturalist 16:135-139.

Roath, L. R. and W.C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. Journal Range Manage. 35:100-103.

Rumble, M.A. and J.E. Gobeille. 1998. Bird community relationships to succession in green ash (*Fraxinus pennslyvanica*) woodland. American Midland Naturalist. 140: 372-381.

Rumble, M.A. C.H. Sieg, D.W. Uresk, and J. Javersak. 1998. Native woodlands and birds of South Dakota: past and present. Research Paper RMS-RP-8. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Research Station. 11pp.

Severson, K, E. and C. E. Boldt. 1978. Cattle, wildlife, and riparian habitats in the western Dakota. Pp. 90-103. in J. C. Shaver, ed. Management and use of northern Plains rangeland. Regional Rangeland Symposium, Bismark ND. North Dakota State University, Fargo.

Severson, K.E. and C.H. Sieg. 2006. The nature of eastern North Dakota: Pre-1880 historical ecology. North Dakota Institute for Regional Studies, North Dakota State University. 308 pp.

Smith, A.D., P.A. Lucas, C.O. Baker and G.W. Scotter. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Aspen Bibliography, Paper 5381, Utah State University. 32pp.

SPSS Inc. 2003. SPSS Base 12 for Windows User Guide. SPSS Inc., Chicago, Illinois.

Stack, R. W. and J. G. Laut. 1986. Dutch elm disease. In Riffle, J.W., G.W. Peterson, Technical Coordinators. Diseases of trees in the Great Plains. Gen. Tech. Rep. RM-129. Fort Collins, CO. USDA, USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. 149 pp.

Uresk, D. W. and W. W. Paintner. 1985. Cattle diets in a ponderosa pine forest in northern Black Hills. Journal Range Management 38:440-442.

Uresk, D.W. and C.E. Boldt. 1986. Effect of cultural treatments on regeneration of native woodlands on the northern Great Plains. Prairie Naturalist 18:193-202.

USDA-NRCS. 2016. The PLANTS Database National Plant Data Team, Greensboro, NC 27401-4901. Available at: http://plants.usda.gov/java/ [Cited 1 November 2016].

Willard, E. E. and C. M. McKell. 1978. Response of shrubs to simulated browsing. Journal Wildlife Management. 42:514-519.

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