Autecology of White Sage on the Northern Mixed Grass Prairie

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The autecology of White Sage, *Artemisia ludoviciana*, is one of the prairie plant species included in a long ecological study conducted at the NDSU Dickinson Research Extension Center during 67 growing seasons from 1946 to 2012 that quantitatively describes the changes in growth and development during the annual growing season life history and the changes in abundance through time as affected by management treatments for the intended purpose of the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains. The introduction to this study can be found in report DREC 16-1093 (Manske 2016).

White sage, *Artemisia ludoviciana* Nutt., is a member of the aster (sunflower) family, Asteraceae, and is a native, perennial, deciduous, warm season subshrub-shrub. Aerial growth has solitary to numerous, erect, herbaceous stems 0.5-3 feet (15-91 cm) tall arising from thick, woody rhizomes; the portions of the rhizome with an aerial stem develop into a thick stem base; stems and leaves are mostly tomentose, covered with soft white fuzzy hairs. Stems die back to the rhizome during winter. The root system has extensive fibrous vertical roots than can descend to 27.5 inches (70 cm) deep. Horizontal lateral roots branch and become intertwined forming a firm mesh in the upper 2 inches (5 cm) of soil. The coarse woody rhizomes remain between 1-5.5 inches (2.5-14 cm) deep forming a dense network that can reach 6.5-10 feet (2-3 m) in diameter; clonal plants with aggressive rhizomes can extend further and develop colonies with 50 foot (15 m) diameters. The colonies develop thicker stem densities with age. Regeneration is by vegetative and sexual reproduction. Vegetative growth is sprouts from rhizomes and older stem bases. Sexual reproduction is from numerous inconspicuous flowers clustered on small heads that emerge during August-September. Pollination is by wind. The seed is a small achene. Fire top kills aerial stems; sprouts develop from rhizomes and older stem bases. This summary information on growth development and regeneration of white sage was based on the works of Stevens 1963, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Anderson 2005, Stevens and Roberts 2006, Johnson and Larson 2007, and Stubbendieck et al. 2011.

Procedures

The 1955-1962 Study

White sage plant growth in height was determined by measuring ungrazed stems from ground level to top of leaf or to the tip of the inflorescence of an average of 10 plants of each species at approximately 7 to 10 day intervals during the growing seasons of 1955 to 1962 from early May until early September. Dates of first flower (anthesis) were recorded as observed. These growth in height and flower data were reported in Goetz 1963.

The 1969-1971 Study

The range of flowering time of White sage was determined by recording daily observations of plants at anthesis on several prairie habitat type collection locations distributed throughout 4,569 square miles of southwestern North Dakota. The daily observed flowering plant data collected during the growing seasons of 1969 to 1971 from April to August were reported as flower sample periods with 7 to 8 day duration in Zaczkowski 1972.

The 1984-1985 Study

White sage plant growth in height was determined by measuring stems from ground level to top of stem or leaf or to the tip of the inflorescence of 12 ungrazed specimens randomly selected on each of the three replications of grazed sandy, shallow, silty, and clayey ecological sites biweekly during June, July, and August of the growing seasons of 1984 and 1985. Phenological growth stage of each specimen was recorded as vegetative, budding, anthesis, seed developing, seed shedding, or mature. Percentage of stem dryness of each specimen was recorded as 0, 0-2, 2-25, 25-50, 50-75, 75-98, or 100 percent dry. Mean stem weight was determined by clipping at ground level 12 specimens at typical phenological growth stages at biweekly sample dates on separate grazed areas of the sandy, shallow, silty, and clayey ecological sites. Clipped stems at each sample site were placed in separate labeled paper bags of known weight, oven dried at 62° C (144° F), and weighed in grams.

The 1983-2012 Study

A long-term study on change in abundance of White sage was conducted during active plant growth of July and August each growing season of 1983 to 2012 (30 years) on native rangeland pastures at the Dickinson Research Extension Center ranch located near Manning, North Dakota. Effects from three management treatments were evaluated: 1) long-term nongrazing, 2) traditional seasonlong grazing, and 3) twice-over rotation grazing. Each treatment had two replications, each with data collection sites on sandy, shallow, and silty ecological sites. Each ecological site of the two grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure. The sandy, shallow, and silty ecological sites were each replicated two times on the nongrazed treatment, three times on the seasonlong treatment, and six times on the twice-over treatment.

During the initial phase of this study, 1983 to 1986, the long-term nongrazed and seasonlong treatments were at different locations and moved to the permanent study locations in 1987. The data collected on those two treatments during 1983 to 1986 were not included in this report.

Abundance of White sage was determined with plant species stem density by 0.1 m^2 frame density method and with plant species basal cover by the ten-pin point frame method (Cook and Stubbendieck 1986).

The stem density method was used to count individual stems of each plant species rooted inside twenty five 0.1 m^2 quadrats placed along permanent transect lines at each sample site both inside (ungrazed) and outside (grazed) each exclosure. Stem density per 0.1 m^2 quadrat, relative stem density, percent frequency, relative percent frequency, and importance value were determined from the stem density data. Plant species stem density data collection was 1984, 1986 to 2012 on the twice-over treatment and was 1987 to 2012 on the long-term nongrazed and seasonlong treatments. However, stem density data was not collected during 1991, 1993 to 1997 on the sandy, shallow, and silty ecological sites of all three management treatments, stem density data was not collected during 1992 on the sandy ecological site of all three management treatments, and stem density data was not collected during 1999 on the sandy and silty ecological sites of the long-term nongrazed treatment.

The point frame method was used to collect data at 2000 points along permanent transect lines at each sample site both inside (ungrazed) and outside (grazed) each exclosure. Basal cover, relative basal cover, percent frequency, relative percent frequency, and importance value were determined from the ten-pin point frame data. Point frame data collection period was 1983 to 2012 on the twice-over treatment and was 1987 to 2012 on the long-term nongrazed and seasonlong treatments. However, point frame data was not collected during 1992 on the sandy ecological sites of all three treatments.

During some growing seasons, the point frame method or the stem density method did not document the presence of a particular plant species which will be reflected in the data summary tables as an 0.00 or as a blank spot.

The 1983-2012 study attempted to quantify the increasing or decreasing changes in individual plant species abundance during 30 growing seasons by comparing differences in the importance values of individual species during multiple year periods. Importance value is an old technique that combines relative density or relative basal cover with relative frequency producing a scale of 0 to 200 that ranks individual species abundance within a plant community relative to the individual abundance of the other species in that community during a growing season. Density importance value ranks the forbs and shrubs and basal cover importance value ranks the grasses, upland sedges, forbs, and shrubs in a community. The quantity of change in the importance values of an individual species across time indicates the magnitude of the increases or decreases in abundance of that species relative to the changes in abundance of the other species.

Results

White sage resumed growth during early spring and developed as a single stalk or as numerous erect annual herbaceous stems from thick, woody rhizomes and formed a thickened stem base at stem-rhizome contact point. The aerial stems can grow in height to 91.4 cm (36 in). The earliest first flowers appeared on 16 July, the mean first flowers occurred on 12 August during the 1955-1962 study, and the flower period occurred from mid August through early September during the 1969-1971 study (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature height of 26.3 cm (10.4 in) with an annual variance in height from 16.0 cm (6.3 in) to 39.0 cm (15.4 in) was reached during August on the fall grazed pastures of the 1955-1962 study (table 2) (Goetz 1963).

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 3,624 white sage stems were sampled during this study, with 1070 stems (29.5%) from the sandy sites, 954 stems (26.3%) from the shallow sites, 891 stems (24.6%) from the silty sites,

and 709 stems (19.6%) from the clayey sites. White sage grows best on sandy sites. White sage grows well on the silty sites of the nongrazed and seasonlong treatments and grows poorly on the silty sites of the twice-over treatment. White sage can grow on the shallow and clayey sites but usually not very well. The mean August height attained and percent of normal height of 91.4 cm (36 in) was 25.3 cm (10.0 in) 27.7% on the sandy site, was 13.0 cm (5.1 in) 14.3% on the shallow site, was 16.9 cm (6.7 in) 18.5% on the silty site, and was 13.3 cm (5.2 in) 14.5% on the clayey site. The tallest mean heights reached were on the sandy sites and the shortest mean heights reached were on the shallow and clayey sites. The mean mature stem height from the 1955-1962 study was 26.3 cm (10.4 in) 28.8% of normal height. The reduced stem heights of white sage on the 1955-1962 study and 1984-1985 study was caused by low quantities of available mineral nitrogen well below the threshold levels of 100 lbs/ac that resulted from the traditional management practices detrimental effects on the biogeochemical processes of the prairie plant community.

Mean white sage stem weights were not significantly different on the four ecological sites. Stem weights were heaviest on the sandy site at 0.39 g, were lightest on the shallow site at 0.24 g, and were second lightest on the silty site at 0.29 g, and on the clayey site at 0.29 g (tables 3, 4, 5, and 6).

As a result of the long active growth period during the full length of the growing season and the late season flower period of white sage, 99.72% of the total stem population were still at the vegetative and budding growth stages through late August and only 0.28% of the stem population had reached the mature phenological growth stages of anthesis and seed developing. Senescence rate of white sage stems was at 30.9% during late August. The aerial stems of white sage die back completely to ground level during winter.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Relative stem abundance of white sage as measured by the density and basal cover importance values (tables 7 and 8) was dynamic during the 30 year study of 1983 to 2012. The density importance value for white sage greatly increased during the low precipitation period of 1988 to 1992, however, white sage stem density decreased during 1988. The density importance values decreased after the growing season precipitation returned to normal levels. The wide changes in the density importance values resulted because of the wide swings in the abundance of the forbs as a group that generally respond rapidly with increases and decreases in stem density in concordance with the dynamic changes in growing season precipitation. The basal cover importance values for white sage increased during the low precipitation period of 1988 to 1992 then deceased to low levels after the growing season precipitation returned to normal levels. The basal cover importance values, however, did not increase and decrease to the great extent that the density importance values changed because the basal cover of grasses and upland sedges oscillate at a much lower magnitude than the fluctuation in growing season precipitation.

White sage stems were present at the beginning of the study on the sandy and silty ecological sites of the nongrazed and seasonlong treatments and on the sandy ecological site of the twice-over treatment. Too few white sage stems were present on the shallow ecological site of the nongrazed, seasonlong, and twice-over treatments to show abundance changes and few white sage stems were present on the silty ecological site of the twice-over treatment.

On the sandy site of the nongrazed treatment, white sage was present during 100.0% and 96.0% of the years that density and basal cover data were collected, with a mean 9.1 stems/m^2 density and a mean 0.48% basal cover, respectively. White sage stems had moderate abundance at the start of the study, the stem density decreased during 1988, however, the relative stem abundance greatly increased during the low precipitation period of 1988 to 1991 as a result of a great reduction of most forbs and some grasses. The greatest increases in white sage relative stem abundance occurred during 1989 and 1990. The relative stem abundance decreased rapidly and remained at moderate levels during 1998 to 2012 as the forbs and grasses increased (tables 7 and 8).

On the sandy sites of the seasonlong treatment, white sage was present on the ungrazed sandy site during 100.0% and 96.0% of the years, with a mean 23.1 stems/m^2 density and a mean 0.91 % basal cover, and on the grazed sandy site during 100.0% and 96.0% of the years that density and basal cover data were collected, with a mean 23.3 stems/m^2 density and a mean 0.90% basal cover, respectively. White sage stems had great abundance at the start of the study, the stem density decreased during 1988, however, the relative stem abundance greatly increased during the low precipitation period of 1988 to 1992 as a result of a great reduction of most forbs and some grasses. The greatest increases in white sage stem relative stem abundance occurred during 1989 and 1990. The relative stem abundance decreased slightly during 1993 to 2003 then decreased to moderate levels during 2004 to 2012 as

the forbs and grasses increased (tables 7 and 8).

On the sandy sites of the twice-over treatment, white sage was present on the ungrazed sandy site during 100.0% and 96.6% of the years, with a mean 9.6 stems/m^2 density and a mean 0.61% basal cover, and on the grazed sandy site during 100.0% and 100.0% of the years that density and basal cover data were collected, with a mean 18.7 stems/m^2 density and a mean 0.72% basal cover, respectively. White sage stems had moderate abundance at the start of the study, the stem density decreased during 1988, however, the relative stem abundance greatly increased during the low precipitation period of 1988 to 1992 as a result of a great reduction of most forbs and some grasses. The greatest increase in white sage relative stem abundance occurred during 1990. The relative stem abundance decreased rapidly and remained at moderate levels during 1998 to 2012 as the forbs and grasses increased (tables 7 and 8).

On the silty site of the nongrazed treatment, white sage was present during 100.0% and 92.3% of the years that density and basal cover data were collected, with a mean 19.1 stems/m^2 density and a mean 0.89% basal cover, respectively. White sage stems had great abundance at the start of the study, the stem density decreased during 1988, however, the relative stem abundance increased during the low precipitation period of 1988 to 1992 as a result of a great reduction of most forbs and some grasses. The greatest increase in white sage relative stem abundance occurred during 1990. The relative stem abundance decreased rapidly and remained at moderate levels duirng 1998 to 2012 as the forbs and grasses increased (tables 7 and 8).

On the silty sites of the seasonlong treatment, white sage was present on the ungrazed silty site during 100.0% and 92.3% of the years, with a mean 18.4 stems/m^2 density and a 0.64% basal cover, and on the grazed silty site during 100.0% and 88.5% of the years that density and basal cover data were collected, with a mean 25.6 stems/m^2 density and a mean 0.84% basal cover, respectively. White sage stems had moderate abundance at the start of the study, the stem density decreased during 1988, however, the relative stem abundance increased during the low precipitation period of 1988 to 1992 as a result of a great reduction of most forbs and some grasses. The greatest increase in white sage relative stem abundance occurred during 1990. The relative stem abundance continued to increase to high levels during 1998 to 2003 and the decreased to moderate levels during 2004 to 2012 as the forbs and grasses increased (tables 7 and 8).

On the silty sites of the twice-over treatment, white sage was present on the ungrazed silty site during 27.3% and 20.0% of the years, with a mean 0.8 stems/m^2 density and a mean 0.02% basal cover, and on the grazed silty site during 54.5% and 40.0% of the years that density and basal cover data were collected, with a mean 0.2 stems/m^2 density and a mean 0.01% basal cover, respectively. White sage stems had extremely low abundance at the start of the study, the stem density decreased slightly during 1988, and the relative stem abundance increased slightly during 1989 during the low precipitation period of 1988 to 1992. The relative stem abundance of white sage was extremely low on the ungrazed and grazed sites of the twice-over treatment during 1998 to 2012 (tables 7 and 8).

Stem density of white sage (table 9) was generally high on the sandy ecological sites at 9.1 stems/m^2 on the nongrazed, and at 14.2 stems/m^2 on the twice-over, and at 23.2 stems/m^2 on the seasonlong treatments, and high on the silty ecological sites at 19.1 stems/m^2 on the nongrazed, and at 22.0 stems/m^2 on the seasonlong treatments. Stem density was low on the silty ecological site at 0.5 stems/m^2 on the twice-over treatment. There was no significant differences between the ungrazed and grazed areas on both ecological sites of the two treatments with grazing. White sage stem densities were significantly greater on the sandy and silty ecological sites of the seasonlong treatment during 1988 to 2003. White sage stem densities on the silty sites of the twice-over treatment were significantly lower than those on the silty sites of the nongrazed and seasonlong treatments. White sage stem densities during 2004 to 2012 were not significantly different on the sandy and silty ecological sites of the nongrazed and seasonlong treatments. White sage stem densities were not significantly different on the sandy site of the nongrazed treatment and on the ungrazed and grazed sandy sites of the twice-over treatment.

Discussion

White sage, *Artemisia ludoviciana*, is a subshrub that is commonly present at high densities but a minor component of healthy mixed grass prairie plant communities. White sage grows very well on the sandy and silty sites of the seasonlong treatment, it grows well on the sandy and silty sites of the nongrazed treatment, and grows well on the sandy sites of the twice-over treatment. White sage can survive on shallow and clayey sites but does not live well and white sage lives poorly on the silty sites of the twice-over treatment. Each year white sage resumes aerial stem growth from thick rhizomes during early spring as single stems or multiple clusters of stems. Vegetative growth in height continues during May, June, July, and August.

Flower buds appear during early June. White sage stems at flower (anthesis) can appear mid July through early September. Erect aerial stems reach maximum mature height during August. Normal height is reported to be 91.4 cm (36 in). Stems growing in fall grazed pastures reached mean mature height at 26.3 cm (10.4 in) (28.8% of the normal height) and stems growing in summer grazed (early June to mid October) pastures reached mean mature height at 25.3 cm (10.0 in) (27.7% of the normal height) on sandy sites, at 16.9 cm (6.7 in) (18.5% of the normal height) on silty sites, at 13.3 cm (5.2 in) (14.5% of the normal height) on clayey sites, and at 13.0 cm (5.1 in) (14.3% of the normal height) on shallow sites. The stem heights collected during the 1955-1962 study and during the 1984-1985 study were much shorter than the normal height of 91.4 cm (36 in) because the soils of both studies had quantities of mineral nitrogen available at much less than the threshold quantity of 100 lbs/ac which resulted from the detrimental effects caused by the traditional management practices on the biogeochemical processes of the prairie plant communities.

Mean stem weights were at 0.39 g on the sandy sites, at 0.29 g on the silty sites, at 0.29 g on the clayey sites, and at 0.24 g on the shallow sites. The sandy sites had the tallest stems that were the heaviest in weight and had densities at 23.2 stems/m^2 on the seasonlong, at 14.2 stems/m^2 on the twice-over, and at 9.1 stems/m^2 on the nongrazed treatments. The silty sites had the second tallest stems at the second heaviest weight and had densities at 22.0 stems/m^2 on the seasonlong, at 19.1 stems/m^2 on the nongrazed, and at 0.5 stems/m^2 on the twice-over treatments. The clayey sites had the second shortest stems at the second lightest weight and had sparse densities. The shallow sites had the shortest stems that had the lightest weight and had sparse densities. As a result of the long active growth period and late season flower period, 99.72% of the total population of white sage stems were still at the vegetative and budding growth stages through August and only 0.28% of the stem population had reached the anthesis and seed developing growth stages. During August, senescence had caused a mean of 26.6% dryness on the white sage stems. The herbaceous aerial stems of white sage die back completely to ground level during winter.

White sage was variously affected by ecosystem type and management treatment, however, white sage does not appear to be directly affected by partial defoliation from grazing.

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Table 1. First flower and flower period of Artemisia ludoviciana, White sage.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest				16		
Mean					12	
Flower Period						
1969-1971					XX	X

First Flower data from Goetz 1963.
Flower Period Data from Zaczkowski 1972.

Table 2. Autecology of Artemisia ludoviciana, White sage, with growing season changes in mature height.

				Percent of Mature Height Attained					
Data Period	Minimum Annual Mature Height cm	Maximum Annual Mature Height cm	Mean Mature Height cm	Apr %	May %	Jun %	Jul %	Aug %	Sep %
1955-1962	16.0	39.0	26.3	10.0	24.2	45.0	84.7	100.0	

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for, Artemisia ludoviciana, White sage, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	93.9	82.5	70.7	68.4	57.9
Bud		6.1	17.5	29.3	31.6	40.7
Anth						0.7
Seed Dev						0.7
Seed Shed						
Mat						
Mean Height (cm)						
Veg	10.2	9.1	8.9	10.6	10.0	9.2
Bud		18.8	12.7	15.2	16.5	16.2
Anth						33.5
Seed Dev						35.0
Seed Shed						
Mat						
% Dryness						
Veg	6.8	10.7	9.9	27.5	34.7	35.3
Bud		1.5	16.4	22.6	25.1	31.0
Anth						2.0
Seed Dev						2.0
Seed Shed						
Mat						
Mean Weight (g)	0.24	0.29	0.29	0.71	0.47	0.35

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 4. Phenological growth stage changes during the growing season for, Artemisia ludoviciana, White sage, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	96.3	99.2	87.4	81.6	64.7	67.5
Bud	3.7	0.8	12.6	18.4	35.3	26.2
Anth						
Seed Dev						6.3
Seed Shed						
Mat						
Mean Height (cm)						
Veg	6.5	5.1	5.5	7.5	7.1	6.7
Bud	8.2	13.1	10.8	12.1	8.6	13.0
Anth						
Seed Dev						17.5
Seed Shed						
Mat						
% Dryness						
Veg	7.7	5.8	15.7	19.5	26.5	27.9
Bud	0.7	2.0	16.9	14.8	22.8	34.9
Anth						
Seed Dev						28.4
Seed Shed						
Mat						
Mean Weight (g)	0.15	0.17	0.32	0.36	0.25	0.20

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 5. Phenological growth stage changes during the growing season for, Artemisia ludoviciana, White sage, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	97.1	97.4	77.4	72.8	58.8	68.8
Bud	2.9	2.6	22.6	27.2	40.2	31.2
Anth						
Seed Dev						
Seed Shed						
Mat						
Mean Height (cm)						
Veg	8.3	7.8	8.3	10.6	10.0	10.1
Bud	13.1	9.4	11.8	17.1	17.5	16.3
Anth						
Seed Dev						
Seed Shed						
Mat						
% Dryness						
Veg	6.7	13.9	19.5	20.7	22.4	16.2
Bud	1.0	7.8	13.6	26.4	26.7	37.1
Anth						
Seed Dev						
Seed Shed						
Mat						
Mean Weight (g)	0.15	0.18	0.36	0.32	0.36	0.39

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 6. Phenological growth stage changes during the growing season for, Artemisia ludoviciana, White sage, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	98.2	97.6	80.3	89.7	60.5	62.2
Bud	1.8	2.4	19.7	10.3	39.5	37.8
Anth						
Seed Dev						
Seed Shed						
Mat						
Mean Height (cm)						
Veg	7.2	6.5	7.1	9.0	9.6	9.2
Bud	16.2	9.6	12.5	16.3	15.9	10.6
Anth						
Seed Dev						
Seed Shed						
Mat						
% Dryness						
Veg	10.2	9.8	10.4	21.3	23.9	32.8
Bud	0.0	2.0	23.4	16.8	33.4	33.8
Anth						
Seed Dev						
Seed Shed						
Mat						
Mean Weight (g)	0.24	0.19	0.35	0.22	0.34	0.38

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 7. Autecology of Artemisia ludoviciana, White sage, with growing season changes in density importance value, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	22.50	0.00	106.18	70.51	63.01
1988-1992	73.83	0.00	123.86	95.47	93.80
1993-1998	33.26	0.00	85.28	37.14	57.30
1999-2003	17.83	12.12	82.23	26.80	59.49
2004-2009	26.46	25.98	28.59	20.64	56.30
2010-2012	15.56	29.79	24.43	24.32	57.68
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	72.04	22.15	24.31	0.89	0.71
1988-1992	64.26	29.37	24.35	3.39	3.52
1993-1998	49.29	28.53	49.61	0.00	0.00
1999-2003	38.81	57.92	76.10	0.13	0.97
2004-2009	46.52	23.06	26.23	0.00	0.39
2010-2012	40.14	41.81	36.29	0.48	0.00

Table 8. Autecology of Artemisia ludoviciana, White sage, with growing season changes in basal cover importance value, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	3.57	0.00	17.73	2.59	4.93
1988-1992	4.18	0.00	19.52	15.59	14.43
1993-1998	9.47	0.00	3.66	5.84	7.39
1999-2003	2.21	1.42	6.14	1.47	4.27
2004-2009	4.43	4.88	2.65	1.03	3.28
2010-2012	0.33	0.50	0.28	0.43	2.19
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	6.50	2.69	6.85	0.45	0.23
1988-1992	16.60	7.60	10.50	0.35	0.03
1993-1998	7.49	4.14	3.20	0.05	0.05
1999-2003	3.48	10.67	8.52	0.00	0.07
2004-2009	6.18	2.89	6.37	0.00	0.03
2010-2012	1.06	0.73	0.57	0.00	0.00

Table 9. Autecology of Artemisia ludoviciana, White sage, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.42	0.00	3.12	1.83	1.57
1988-1992	1.59	0.00	3.35	1.86	1.93
1993-1998	1.50	0.00	2.33	0.62	1.60
1999-2003	0.72	3.08	3.92	0.60	2.32
2004-2009	0.90	1.09	1.24	0.54	1.60
2010-2012	0.46	0.95	0.54	0.64	2.02
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	2.62	1.51	1.92	0.02	0.04
1988-1992	1.82	0.67	0.59	0.02	0.04
1993-1998	2.04	1.85	2.36	0.00	0.00
1999-2003	1.74	4.51	6.38	0.00	0.02
2004-2009	2.22	0.93	1.65	0.00	0.01
2010-2012	1.35	0.90	0.89	0.00	0.00

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Appendix
Autecology Data of White Sage

Table 1.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1984.												
	8 Jun							23 Jun					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population								90.5	9.5				
Mean Height (cm)								7.2	18.8				
% Dryness								6.3	1.5				
Mean Weight (g)	0.18												
	8 Jul							23 Jul					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	75.6	24.4						65.3	34.7				
Mean Height (cm)	7.7	12.9						9.5	12.9				
% Dryness	6.0	4.2						19.3	19.6				
Mean Weight (g)	0.32							1.03					
	8 Aug							23 Aug					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	58.3	41.7						38.9	61.1				
Mean Height (cm)	10.6	17.3						9.2	16.3				
% Dryness	35.5	28.7						47.3	38.4				
Mean Weight (g)	0.58							0.33					

Table 2.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1985.												
	8 Jun							23 Jun					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	100.0							100.0					
Mean Height (cm)	10.2							12.1					
% Dryness	6.8							15.1					
Mean Weight (g)	0.34							0.29					
	8 Jul							23 Jul					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	89.7	10.3						76.0	24.0				
Mean Height (cm)	9.9	12.1						11.6	18.3				
% Dryness	13.8	28.5						35.6	25.6				
Mean Weight (g)	0.19							0.46					
	8 Aug							23 Aug					
Site: Sandy	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	77.5	22.5						77.9	19.1	1.5	1.5		
Mean Height (cm)	9.6	15.2						9.2	15.8	33.5	35.0		
% Dryness	33.8	21.4						23.2	23.6	2.0	2.0		
Mean Weight (g)	0.41							0.36					

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 3.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1984.												
	8 Jun							23 Jun					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population								100.0					
Mean Height (cm)								4.6					
% Dryness								3.6					
Mean Weight (g)	0.13												
	8 Jul							23 Jul					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	81.5	18.5						72.2	27.8				
Mean Height (cm)	4.9	9.8						7.3	12.0				
% Dryness	5.2	8.7						17.1	16.1				
Mean Weight (g)	0.32							0.46					
	8 Aug							23 Aug					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	48.6	51.4						52.8	36.1		11.1		
Mean Height (cm)	7.2	8.2						6.3	13.2		17.5		
% Dryness	27.7	34.8						32.6	33.7		28.4		
Mean Weight (g)	0.38							0.31					

Table 4.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1985.												
	8 Jun							23 Jun					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	96.3	3.7						97.2	2.8				
Mean Height (cm)	6.5	8.2						6.4	13.1				
% Dryness	7.7	0.7						8.0	2.0				
Mean Weight (g)	0.22							0.17					
	8 Jul							23 Jul					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	95.5	4.5						91.3	8.7				
Mean Height (cm)	6.1	16.3						7.7	12.1				
% Dryness	26.1	25.0						21.8	13.5				
Mean Weight (g)	0.23							0.21					
	8 Aug							23 Aug					
Site: Shallow	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	79.5	20.5						87.0	13.0				
Mean Height (cm)	7.1	9.5						7.0	12.3				
% Dryness	25.2	10.8						23.1	36.0				
Mean Weight (g)	0.18							0.13					

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 5.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1984.												
	8 Jun							23 Jun					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population								95.6	4.4				
Mean Height (cm)								7.0	9.4				
% Dryness								4.9	7.8				
Mean Weight (g)	0.13												
	8 Jul							23 Jul					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	72.5	27.5						66.7	33.3				
Mean Height (cm)	6.9	11.3						9.5	15.1				
% Dryness	6.1	3.6						23.7	29.2				
Mean Weight (g)	0.47							0.43					
	8 Aug							23 Aug					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	50.0	50.0						56.3	43.8				
Mean Height (cm)	11.5	16.3						9.3	15.8				
% Dryness	21.9	31.2						35.3	54.8				
Mean Weight (g)	0.56							0.38					

Table 6.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1985.												
	8 Jun							23 Jun					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	97.1	2.9						100.0					
Mean Height (cm)	8.3	13.1						8.9					
% Dryness	6.7	1.0						22.9					
Mean Weight (g)	0.19							0.18					
	8 Jul							23 Jul					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	82.7	17.3						79.6	20.4				
Mean Height (cm)	9.6	12.6						11.5	20.6				
% Dryness	32.9	23.5						17.6	23.5				
Mean Weight (g)	0.21							0.25					
	8 Aug							23 Aug					
Site: Silty	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat		Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	68.7	31.3						87.5	12.5				
Mean Height (cm)	9.1	19.3						10.9	19.0				
% Dryness	22.9	22.1						23.1	19.3				
Mean Weight (g)	0.26							0.40					

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 7.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1984.												
	8 Jun						23 Jun						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population							95.7	4.3				
Mean Height (cm)							5.7	9.6				
% Dryness							3.5	2.0				
Mean Weight (g)	0.26											
	8 Jul						23 Jul						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	71.2	28.8					85.4	14.6				
Mean Height (cm)	4.7	13.0					9.1	15.7				
% Dryness	4.5	5.1					13.9	20.0				
Mean Weight (g)	0.36						0.33					
	8 Aug						23 Aug						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	39.6	60.4					50.0	50.0				
Mean Height (cm)	8.8	14.5					9.5	12.7				
% Dryness	33.2	37.2					41.8	42.9				
Mean Weight (g)	0.35						0.46					

Table 8.	Autecology study of Artemisia ludoviciana with growing season changes in phenological growth stage,												
	mean height, and mean weight, 1985.												
	8 Jun						23 Jun						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	98.2	1.8					100.0					
Mean Height (cm)	7.2	16.2					7.4					
% Dryness	10.2	0.0					16.0					
Mean Weight (g)	0.19						0.19					
	8 Jul						23 Jul						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	90.2	9.8					94.9	5.1				
Mean Height (cm)	9.2	11.0					8.9	18.7				
% Dryness	16.3	41.7					28.7	13.5				
Mean Weight (g)	0.33						0.15					
	8 Aug						23 Aug						
Site: Clayey	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat	Veg	Bud	Anth	Seed Dev	Seed Shed	Mat
% Population	86.8	13.2					79.4	20.6				
Mean Height (cm)	10.0	23.7					9.0	15.5				
% Dryness	14.5	29.5					23.8	24.6				
Mean Weight (g)	0.34						0.34					

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 9.	Density analysis for native range on the nongrazed grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NG-W & E				Relative	
Site:	Sandy, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		0.42	12.50	4.76	10.00	22.50
1988		0.40	26.19	19.76	23.32	49.51
1989		2.16	54.55	16.16	30.19	84.73
1990		2.20	56.27	11.70	31.00	87.26
1991		No Densities Collected				
1992		No Densities Collected				
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		1.50	17.52	3.97	15.74	33.26
1999		No Densities Collected				
2000		0.75	8.76	1.99	7.87	16.63
2001		0.82	7.62	24.00	9.95	17.57
2002		0.96	7.88	20.00	8.21	16.09
2003		0.34	10.03	20.00	10.99	21.02
2004		0.18	7.26	14.00	9.28	16.54
2005		0.48	10.44	20.00	12.22	22.67
2006		2.12	27.60	48.00	13.79	41.40
2007		1.48	24.50	50.00	16.23	40.74
2008		0.68	16.35	28.00	12.07	28.42
2009		0.48	4.71	16.00	4.30	9.01
2010		0.36	9.09	20.00	7.58	16.67
2011		0.48	6.09	22.00	6.32	12.41
2012		0.54	11.07	18.00	6.52	17.59

Table 10	Density analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12				Relative	
Site:	Sandy, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987						
1988						
1989						
1990						
1991		No Densities Collected				
1992		No Densities Collected				
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998						
1999						
2000						
2001						
2002						
2003		3.08	37.56	58.67	23.04	60.60
2004		1.92	25.21	34.67	15.19	40.39
2005		0.99	14.84	32.00	11.97	26.81
2006		1.81	19.05	36.00	13.21	32.26
2007		0.68	15.76	33.33	12.58	28.34
2008		0.83	11.85	24.00	10.21	22.06
2009		0.31	2.56	10.67	3.46	6.03
2010		0.75	17.13	25.33	15.44	32.58
2011		0.33	7.44	17.33	8.02	15.47
2012		1.76	23.18	40.00	18.13	41.31

Table 11.	Density analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12				Relative	
Site:	Sandy, grazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		3.12	63.54	70.67	42.65	106.18
1988		1.24	54.59	48.00	38.35	92.93
1989		3.45	73.05	84.00	52.34	125.39
1990		5.35	90.66	78.67	62.60	153.26
1991		No Densities Collected				
1992		No Densities Collected				
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		2.33	49.12	57.33	36.17	85.28
1999		3.72	54.44	13.12	38.41	92.85
2000		4.47	47.18	65.33	28.45	75.63
2001		4.01	45.35	64.00	21.76	67.11
2002		3.79	59.25	68.00	34.35	93.60
2003		3.63	51.54	72.00	30.41	81.95
2004		1.75	30.18	38.67	18.58	48.75
2005		1.89	20.20	40.00	11.72	31.92
2006		0.92	21.22	40.00	17.24	38.46
2007		2.17	19.28	45.33	12.01	31.29
2008		0.40	6.84	20.00	8.08	14.92
2009		0.32	2.34	13.33	3.84	6.18
2010		0.63	14.82	26.67	15.33	30.15
2011		0.16	3.67	6.67	3.47	7.14
2012		0.83	21.47	29.33	14.53	36.00

Table 12.	Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6				Relative	
Site:	Sandy, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Densities Collected				
1984		0.92	32.01	38.00	21.76	53.78
1985		No Densities Collected				
1986		1.89	43.53	52.00	25.89	69.42
1987		2.69	53.60	59.33	34.74	88.34
1988		1.37	61.48	68.00	53.41	114.89
1989		1.04	30.36	33.33	23.08	53.44
1990		3.18	67.42	61.33	50.67	118.09
1991		No Densities Collected				
1992		No Densities Collected				
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		0.62	18.73	32.67	18.41	37.14
1999		0.67	18.00	9.86	18.08	36.08
2000		0.77	14.88	28.00	15.04	29.92
2001		0.97	15.10	30.00	14.86	29.96
2002		0.67	12.86	28.00	13.99	26.85
2003		0.31	4.70	14.00	6.47	11.17
2004		0.62	12.00	22.00	11.97	23.96
2005		0.27	6.00	12.00	6.10	12.10
2006		0.41	8.01	17.33	9.68	17.69
2007		0.70	10.14	59.33	15.25	25.39
2008		0.41	11.61	17.33	11.00	22.62
2009		0.81	13.45	19.33	8.60	22.05
2010		0.87	20.33	28.00	15.09	35.42
2011		0.27	3.12	7.33	2.92	6.04
2012		0.79	16.43	30.00	15.07	31.50

Table 13.	Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6				Relative	
Site:	Sandy, grazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Densities Collected				
1984		1.10	35.12	41.33	22.61	57.73
1985		No Densities Collected				
1986		1.39	38.04	43.33	22.12	60.16
1987		2.23	45.28	50.00	25.86	71.14
1988		1.22	50.95	59.33	41.91	92.86
1989		1.45	42.47	44.67	27.68	70.15
1990		3.11	72.29	60.00	46.10	118.39
1991		No Densities Collected				
1992		No Densities Collected				
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		1.60	36.33	36.67	20.97	57.30
1999		2.01	27.51	13.91	15.90	43.41
2000		2.31	40.26	40.67	22.38	62.64
2001		2.72	35.54	45.33	19.67	55.22
2002		2.39	39.63	53.33	29.20	68.83
2003		2.17	37.97	54.00	29.40	67.36
2004		1.19	33.44	43.33	25.79	59.23
2005		1.07	19.61	30.67	12.03	31.64
2006		1.62	33.44	43.33	22.99	56.44
2007		2.21	39.20	48.00	21.72	60.92
2008		1.45	47.39	45.33	34.34	81.73
2009		2.05	30.52	40.00	17.30	47.82
2010		1.86	38.25	49.33	26.83	65.08
2011		1.27	17.25	24.67	10.90	28.14
2012		2.92	48.13	58.67	31.70	79.83

Table 14.	Points analysis for native range on the nongrazed grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NG-W & E		Relative		Relative	
Site:	Sandy, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		0.40	1.70	3.50	1.87	3.57
1988		1.50	5.47	11.50	6.05	11.52
1989		0.35	1.43	3.50	2.08	3.52
1990		0.10	0.61	1.00	0.69	1.30
1991		0.05	0.16	0.50	0.23	0.39
1992		No Points Collected				
1993		2.05	6.63	15.00	7.33	13.96
1994		0.60	4.95	5.50	5.00	9.95
1995		2.03	10.61	17.25	10.90	21.51
1996		0.50	2.33	5.00	2.91	5.23
1997		0.20	0.89	2.00	1.14	2.03
1998		0.25	2.05	2.25	2.11	4.16
1999		0.15	0.84	1.25	0.88	1.72
2000		0.13	0.63	1.25	0.81	1.44
2001		0.33	1.20	2.75	1.36	2.56
2002		0.20	0.72	2.00	1.03	1.75
2003		0.40	1.53	3.50	2.07	3.60
2004		0.15	0.64	1.25	0.73	1.37
2005		0.33	1.19	3.00	1.55	2.74
2006		1.25	5.52	11.00	5.91	11.43
2007		0.65	3.45	6.50	3.88	7.33
2008		0.20	1.41	2.00	1.64	3.05
2009		0.05	0.29	0.50	0.35	0.64
2010						
2011		0.05	0.22	0.50	0.30	0.52
2012		0.05	0.21	0.50	0.27	0.48

Table 15.	Points analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12		Relative		Relative	
Site:	Sandy, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987						
1988						
1989						
1990						
1991						
1992		No Points Collected				
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003		0.83	3.22	7.50	3.89	7.10
2004		1.13	3.98	8.33	3.78	15.10
2005		0.73	2.74	6.33	2.97	5.71
2006		0.27	1.27	2.50	1.47	2.74
2007		0.33	1.55	3.33	1.91	3.45
2008		0.13	0.83	1.33	0.99	1.82
2009		0.03	0.21	0.33	0.25	0.46
2010		0.07	0.40	0.50	0.36	0.76
2011						
2012		0.08	0.30	0.83	0.42	0.73

Table 16.	Points analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12		Relative		Relative	
Site:	Sandy, grazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		2.40	8.48	19.67	9.25	17.73
1988		2.80	10.51	24.43	11.32	21.83
1989		4.17	12.52	25.67	10.78	23.30
1990		4.57	14.34	37.33	17.02	31.36
1991		0.13	0.73	1.33	0.87	1.60
1992		No Points Collected				
1993		0.03	0.17	0.33	0.26	0.43
1994		0.90	3.80	8.33	4.92	8.73
1995		0.42	2.22	4.00	2.45	4.66
1996		0.37	1.10	3.67	1.54	2.64
1997		0.47	1.52	4.67	2.10	3.62
1998		0.18	0.79	1.83	1.06	1.85
1999		1.12	3.80	9.33	4.21	8.01
2000		0.55	2.20	5.00	2.76	4.95
2001		0.25	0.81	2.50	1.16	1.97
2002		0.82	3.35	7.67	4.10	7.45
2003		1.03	3.86	9.17	4.46	8.33
2004		1.05	3.49	8.67	3.91	7.39
2005		0.65	2.16	5.50	2.40	4.56
2006		0.25	0.93	2.50	1.25	2.18
2007		0.07	0.21	0.67	0.30	0.51
2008		0.10	0.48	1.00	0.62	1.10
2009		0.02	0.07	0.17	0.10	0.17
2010		0.07	0.23	0.67	0.34	0.57
2011						
2012		0.03	0.11	0.33	0.16	0.26

Table 17.	Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6		Relative		Relative	
Site:	Sandy, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983						
1984		0.44	1.33	4.03	1.64	2.97
1985		0.32	1.38	3.17	1.75	3.14
1986		0.49	1.96	4.90	2.28	4.24
1987		2.43	9.19	19.19	9.18	18.37
1988		2.93	8.58	23.98	9.58	18.16
1989		1.61	7.43	14.54	8.37	15.80
1990		3.21	13.49	28.52	14.14	27.63
1991		0.08	0.37	0.83	0.41	0.78
1992		No Points Collected				
1993		1.75	4.63	13.83	6.10	10.73
1994		0.80	3.99	7.83	4.79	8.78
1995		1.37	5.95	13.08	6.59	12.55
1996		0.20	0.67	2.00	0.98	1.65
1997		0.10	0.39	1.00	0.48	0.87
1998		0.03	0.21	0.25	0.24	0.45
1999		0.18	0.82	1.75	1.03	1.84
2000		0.08	0.49	0.75	0.58	1.06
2001		0.08	0.39	0.83	0.51	0.90
2002		0.13	0.64	1.25	0.82	1.46
2003		0.20	0.96	1.92	1.14	2.10
2004		0.13	0.55	1.33	0.72	1.27
2005		0.22	0.93	1.67	0.89	1.82
2006		0.07	0.49	0.67	0.58	1.07
2007		0.01	0.06	0.08	0.07	0.13
2008		0.05	0.49	0.50	0.57	1.06
2009		0.06	0.39	0.58	0.47	0.85
2010		0.06	0.28	0.58	0.36	0.64
2011		0.03	0.22	0.25	0.21	0.43
2012		0.02	0.10	0.17	0.12	0.22

Table 18.	Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6		Relative		Relative	
Site:	Sandy, grazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		0.25	0.50	2.35	0.77	1.27
1984		0.55	1.68	5.49	2.34	4.02
1985		0.31	1.29	3.14	1.59	2.87
1986		0.41	1.88	3.96	2.23	4.11
1987		1.47	5.78	12.98	6.58	12.36
1988		1.83	6.89	15.08	7.43	14.32
1989		1.69	8.40	15.71	9.23	17.62
1990		2.72	10.92	23.64	11.41	22.32
1991		0.37	1.62	3.67	1.84	3.46
1992		No Points Collected				
1993		1.82	4.22	11.33	5.09	9.31
1994		1.38	6.90	12.33	7.38	14.28
1995		1.17	5.22	11.42	5.68	10.89
1996		0.72	2.10	7.00	3.19	5.29
1997		0.30	0.90	2.83	1.22	2.12
1998		0.16	1.20	1.42	1.25	2.45
1999		0.43	1.41	3.92	1.78	3.20
2000		0.38	1.42	3.50	1.86	3.29
2001		0.38	1.27	3.58	1.73	2.99
2002		0.54	1.93	4.92	2.40	4.33
2003		0.85	3.34	7.67	4.22	7.56
2004		0.86	2.98	7.42	3.52	6.50
2005		0.64	2.17	5.67	2.52	4.69
2006		0.18	0.74	1.75	1.00	1.74
2007		0.26	0.94	2.50	1.24	2.18
2008		0.28	1.33	2.83	1.71	3.04
2009		0.15	0.67	1.42	0.85	1.52
2010		0.30	1.12	2.92	1.50	2.63
2011		0.22	0.94	1.58	0.92	1.86
2012		0.25	0.89	2.42	1.18	2.08

Table 19.	Density analysis for native range on the nongrazed grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NG-W & E				Relative	
Site:	Silty, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		2.62	45.33	10.07	26.71	72.04
1988		1.04	25.49	6.86	17.95	43.44
1989		2.28	29.38	4.90	19.00	48.38
1990		3.42	67.40	16.42	43.92	111.32
1991		No Densities Collected				
1992		0.54	30.00	12.22	23.91	53.91
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		2.04	27.19	7.01	22.10	49.29
1999		No Densities Collected				
2000		2.46	28.04	44.00	19.79	47.83
2001		1.70	11.72	36.00	10.11	21.83
2002		1.38	15.66	38.00	14.07	29.74
2003		1.40	32.18	52.00	23.67	55.85
2004		0.52	32.41	30.00	27.58	59.98
2005		0.54	5.79	26.00	8.72	14.51
2006		5.02	45.31	50.00	27.17	72.48
2007		4.14	39.35	50.00	24.04	63.39
2008		2.02	28.06	44.00	18.03	46.09
2009		1.08	11.11	42.00	11.54	22.65
2010		0.36	9.09	20.00	7.58	16.67
2011		1.82	32.04	50.00	21.93	53.97
2012		1.88	31.76	44.00	18.03	49.79

Table 20.	Density analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12				Relative	
Site:	Silty, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		1.51	13.05	29.33	9.10	22.15
1988		0.09	5.98	9.33	7.07	13.05
1989		0.35	7.02	28.00	9.95	16.96
1990		1.99	42.27	29.33	18.40	60.67
1991		No Densities Collected				
1992		0.25	13.97	12.00	12.81	26.78
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		1.85	17.49	32.00	11.04	28.53
1999		2.39	32.74	5.36	24.54	57.27
2000		3.47	33.38	38.67	24.03	57.40
2001		4.53	29.80	36.00	17.08	46.88
2002		5.13	27.85	33.33	14.62	42.47
2003		7.03	54.84	61.33	30.72	85.56
2004		1.11	22.24	29.33	14.79	37.04
2005		0.73	8.50	24.00	6.27	14.77
2006		0.76	18.78	24.00	11.74	30.53
2007		1.57	13.29	28.00	8.97	22.26
2008		0.95	14.02	22.67	9.62	23.64
2009		0.43	5.08	20.00	5.00	10.09
2010		0.35	19.26	18.67	14.58	33.84
2011		1.08	24.43	29.33	15.46	39.89
2012		1.27	30.74	37.33	20.96	51.70

Table 21.	Density analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12				Relative	
Site:	Silty, grazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		1.92	14.60	28.00	9.71	24.31
1988		0.09	5.98	9.33	7.07	13.05
1989		0.12	7.32	12.00	9.15	16.47
1990		1.92	27.12	25.33	14.73	41.85
1991		No Densities Collected				
1992		0.23	14.91	10.67	11.11	26.02
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998		2.36	31.16	33.33	18.45	49.61
1999		5.04	50.59	5.10	21.56	72.15
2000		7.04	56.22	52.00	26.75	82.97
2001		5.96	44.99	57.33	20.01	65.00
2002		7.31	52.50	64.00	22.79	75.29
2003		6.57	57.21	61.33	27.88	85.09
2004		2.68	26.48	24.00	10.91	37.39
2005		1.88	19.11	28.00	8.43	27.54
2006		3.20	24.84	33.33	10.96	35.81
2007		0.73	14.67	33.33	11.74	26.40
2008		0.88	11.64	26.67	9.39	21.03
2009		0.52	5.10	18.67	4.13	9.23
2010		0.48	19.67	20.00	14.71	34.38
2011		1.13	17.82	29.33	11.64	29.46
2012		1.07	26.94	25.33	18.10	45.03

Table 22.	Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6				Relative	
Site:	Silty, ungrazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Densities Collected				
1984						
1985		No Densities Collected				
1986		0.01	0.13	0.67	0.21	0.33
1987		0.05	0.98	4.00	1.36	2.34
1988		0.01	0.58	1.33	0.74	1.33
1989		0.08	6.69	3.33	5.53	12.22
1990						
1991		No Densities Collected				
1992						
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998						
1999						
2000						
2001						
2002						
2003		0.01	0.07	0.67	0.57	0.64
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011		0.01	0.44	1.33	1.01	1.45
2012						

Table 23.	Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6				Relative	
Site:	Silty, grazed		Relative	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Density	Density	Frequency	Frequency	Value
1983		No Densities Collected				
1984						
1985		No Densities Collected				
1986		0.05	0.84	2.00	0.68	1.52
1987		0.06	0.67	4.00	1.38	2.05
1988		0.03	1.23	2.00	1.06	2.30
1989		0.13	6.12	6.00	5.64	11.76
1990						
1991		No Densities Collected				
1992						
1993		No Densities Collected				
1994		No Densities Collected				
1995		No Densities Collected				
1996		No Densities Collected				
1997		No Densities Collected				
1998						
1999		0.01	0.42	0.42	0.79	1.21
2000						
2001		0.04	0.35	0.67	0.16	0.51
2002		0.01	0.46	1.33	0.81	1.27
2003		0.05	1.42	0.67	0.44	1.86
2004		0.01	0.49	0.67	0.45	0.94
2005		0.01	0.05	0.67	0.21	0.26
2006		0.03	0.28	1.33	0.55	0.82
2007		0.01	0.12	0.67	0.21	0.34
2008						
2009						
2010						
2011						
2012						

Table 24.	Points analysis for native range on the nongrazed grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NG-W & E		Relative		Relative	
Site:	Silty, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		0.85	3.14	7.00	3.37	6.50
1988		1.30	5.65	10.00	5.52	11.18
1989		6.85	15.47	40.50	14.72	30.19
1990		3.15	14.67	25.50	15.54	30.22
1991						
1992		1.20	5.24	11.00	6.19	11.43
1993		1.45	4.97	13.50	6.96	11.92
1994		1.00	8.43	10.00	8.92	17.35
1995		1.28	6.32	11.25	6.51	12.83
1996		0.20	0.82	2.00	1.16	1.97
1997		0.10	0.38	1.00	0.49	0.87
1998						
1999		0.40	2.34	3.75	2.70	5.05
2000		0.30	1.10	2.50	1.24	2.34
2001		0.28	0.89	2.25	1.09	1.99
2002		0.45	1.68	4.25	2.21	3.88
2003		0.45	1.74	3.75	2.39	4.14
2004		0.20	0.89	2.00	1.17	2.06
2005		0.33	1.23	3.00	1.63	2.86
2006		1.18	5.72	10.75	6.52	12.23
2007		1.40	6.51	11.50	6.80	13.32
2008		0.33	2.10	3.25	2.36	4.46
2009		0.18	0.98	1.75	1.17	2.15
2010		0.18	0.77	1.75	1.00	1.77
2011		0.03	0.13	0.25	0.16	0.29
2012		0.10	0.50	1.00	0.62	1.11

Table 25.	Points analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12		Relative		Relative	
Site:	Silty, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		0.30	1.19	3.00	1.50	2.69
1988		0.97	2.90	8.00	3.54	6.45
1989		1.20	4.74	10.67	5.25	10.00
1990		3.27	9.35	19.33	8.46	17.81
1991						
1992		0.23	1.75	2.33	1.99	3.75
1993		0.17	0.48	1.67	0.85	1.33
1994		0.67	2.76	6.67	3.61	6.37
1995		0.55	2.46	5.00	2.60	5.06
1996		0.47	2.24	4.00	2.42	4.66
1997		0.40	1.40	4.00	2.19	3.59
1998		0.17	1.85	1.50	1.97	3.82
1999		0.83	3.19	7.33	4.67	7.86
2000		0.58	3.36	4.83	4.48	7.84
2001		1.82	5.25	12.67	7.84	13.10
2002		1.57	7.91	10.33	8.50	16.42
2003		1.00	3.76	8.33	4.37	8.13
2004		1.32	4.65	8.67	3.89	8.54
2005		0.25	0.96	2.33	1.10	2.06
2006		0.35	1.52	3.17	1.63	3.16
2007		0.30	1.27	3.00	1.51	2.78
2008		0.07	0.36	0.67	0.42	0.79
2009						
2010		0.12	0.48	1.17	0.61	1.09
2011		0.05	0.28	0.50	0.34	0.62
2012		0.05	0.19	0.50	0.28	0.47

Table 26.	Points analysis for native range on the 4.5 month seasonlong grazing system at the Dickinson Research Extension Center.					
System:	West/East/North					
Pasture:	NR-9-12		Relative		Relative	
Site:	Silty, grazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		No Data				
1984		No Data				
1985		No Data				
1986		No Data				
1987		1.00	3.26	8.67	3.60	6.85
1988		4.57	14.01	19.67	9.74	23.74
1989		1.90	8.54	17.00	8.88	17.43
1990		1.43	4.94	8.67	4.56	9.50
1991						
1992		0.17	0.76	1.67	1.05	1.81
1993						
1994		0.60	3.47	5.17	3.48	6.95
1995		0.26	1.41	2.28	1.51	2.92
1996		0.63	1.51	5.67	2.22	3.73
1997		0.47	1.21	4.67	1.91	3.13
1998		0.15	1.13	1.33	1.33	2.46
1999		0.62	1.74	5.33	2.23	3.97
2000		0.87	3.43	8.17	4.39	7.82
2001		0.52	1.85	4.00	2.05	3.90
2002		1.47	5.14	12.83	5.73	10.87
2003		1.97	8.15	15.33	7.90	16.05
2004		2.13	7.57	13.83	6.43	14.00
2005		1.65	6.48	11.67	5.61	12.09
2006		0.87	3.79	7.50	4.02	7.81
2007		0.25	1.12	2.33	1.26	2.38
2008		0.08	0.41	0.83	0.48	0.89
2009		0.12	0.56	0.83	0.47	1.03
2010		0.15	0.70	1.33	0.74	1.43
2011						
2012		0.03	0.11	0.33	0.16	0.27

Table 27.	Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6		Relative		Relative	
Site:	Silty, ungrazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983						
1984						
1985						
1986						
1987		0.20	0.78	1.95	1.00	1.78
1988		0.02	0.08	0.17	0.09	0.17
1989		0.05	0.20	0.33	0.18	0.38
1990						
1991		0.08	0.34	0.67	0.37	0.71
1992		0.06	0.23	0.52	0.27	0.51
1993						
1994						
1995		0.03	0.14	0.33	0.16	0.31
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						

Table 28.	Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center.					
System:	West/East					
Pasture:	NR-1-6		Relative		Relative	
Site:	Silty, grazed	Basal	Basal	Percent	Percent	Importance
Species:	Artemisia ludoviciana	Cover	Cover	Frequency	Frequency	Value
1983		0.03	0.04	0.33	0.09	0.14
1984						
1985						
1986		0.10	0.29	1.00	0.43	0.71
1987		0.03	0.12	0.36	0.16	0.28
1988						
1989		0.02	0.07	0.17	0.08	0.15
1990						
1991						
1992						
1993						
1994						
1995						
1996		0.02	0.07	0.17	0.11	0.18
1997						
1998		0.01	0.07	0.08	0.08	0.14
1999						
2000		0.01	0.02	0.08	0.04	0.07
2001		0.01	0.02	0.08	0.04	0.06
2002		0.01	0.04	0.08	0.06	0.10
2003		0.02	0.05	0.17	0.08	0.13
2004		0.02	0.05	0.17	0.07	0.12
2005		0.01	0.02	0.08	0.04	0.06
2006						
2007						
2008						
2009						
2010						
2011						
2012						