Autecology of Purple Locoweed on the Northern Mixed Grass Prairie

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Report DREC 17-1120

The autecology of Purple locoweed, *Oxytropis lambertii,* 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).

Purple locoweed, *Oxytropis lambertii* Pursh., is member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bolley 1891. Annual aerial growth has, no stems (acaulescent), only a stout, thick, branched or knobby crown (caudex) from which the basal leaves and leafless flower stalks arise. Basal leaves are alternate in a tufted rosette, odd pinnately compound 4-20 cm (1.6-7.9 in) long, with 7 to 19 well separated leaflets, linear to oblong, 5-40 mm long, 2-7 mm wide, with both surfaces pubescent. The root system consists of a main stout taproot and a few to several main roots that produce few to no branches and can descend 3.0 to 3.7 m (10-12 ft) in loose soil. These roots absorb water throughout the entire length. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual leaf and flower stalk shoots from the crown and crown branches. Inflorescence has 10 to 20 flowers in a cluster forming a raceme on top of a stout, erect, scape 10-35 cm (3.9-13.8 in) tall. Flowers are perfect, pea-shaped with 5 reddish purple petals, 2 cm (0.8 in) long, appearing during early May to early July. Fruit is a cylindrical legume pod, 3 cm (1.2 in) long with a pointed beak and numerous brown bean shaped seeds. Aerial parts are not eaten by livestock and are top killed by fire. Damage to aerail parts activates regrowth shoots from the crown and the crown branches. This summary information on growth development and regeneration of purple locoweed was based on works of Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Larson and Johnson 2007, and Stubbendieck et al. 2011.

Procedures

The 1955-1962 Study

Purple locoweed, 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 Purple locoweed 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

Purple locoweed 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 42 ungrazed specimens randomly selected on 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 6 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 Purple locoweed 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 Purple locoweed 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 the community during a growing season. Density importance value ranks the forb 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 value 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

Purple locoweed resumed growth early in spring as a rosette of long pinnately compound basal leaves with an odd number of leaflets. No stems develop. The inflorescence of 10 to 20 pea-shaped flowers develop on leafless stalks. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 1 may, the mean first flowers occurred on 26 May, and the long flower period, from the 1969-1971 study, extended eight weeks from early May to the end of June (table 1) (Goetz 1963, Zaczkowski 1972). A mean flower stalk height of 18.1 cm (7.1 in) with an annual variance in height

from 10.0 cm (3.9 in) to 31.0 cm (12.2 in) was reached during Junet (table 2) (Goetz 1963). The reported normal mature flower stalk height in the Northern Plains ranged from 10 cm to 35 cm (3.9-13.8 in) tall. The mean flower stalk heights from the 1955-1962 study were within the normal range for the Northern Plains.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 2,327 Purple locoweed flower stalks and basal leaves were sampled during this study with, 658 stems (28.3%) from the sandy sites, 734 stems (31.5%) from the shallow sites, 524 stems (22.5%) from the silty sites, and 471 stems (17.7%) from the clayey sites. Purple locoweed can grow on sandy, shallow, silty, and clayey ecological sites, it appears to grow better on the sandy and shallow sites than on the silty and clayey sites. The mean mature flower stalk height reached during June were not significantly different with, 18.0 cm (7.1 in) on the sandy sites, 15.6 cm (6.1 in) on the shallow sites, 16.6 cm (6.5 in) on the silty sites, and 17.1 cm (6.7 in) on the clayey sites. The mean flower stalk heights from the 1984-1985 study were all within the normal range for the Northern Plains. Mean Purple locoweed stem weights were not significantly different with, 2.34 g on the dansy sites, 1.59 g on the shallow sites, 1.75 g on the silty sites, and 1.31 g on the clayey sites.

During the growing season, the percentage of Purple locoweed stalks that had passed through the anthesis phenological growth stages was 86.2% by early June, and 94.6% by late June. A few late stalks flowered by the end the first week in July. Some stalks appeared to remain vegetative. However, about 34.2% of the measured stalks were actually sterile scapiform basal leaves, not flower stalks.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. All of the plant communities on all management treatments greatly improved in species composition and plant density in a few years after the start of the studies in 1983. The presence of Purple locoweed greatly decreased on the silty sites. Patterns in the changes in Purple locoweed abundance was followed for 30 growing seasons during the 1983-2012 study on the sandy and shallow ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments.

On the sandy site of the nongrazed treatment, Purple locoweed was present during 16.7% and 8.0% of the years that density and basal cover data were collected, with a mean 0.04 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Purple locoweed was present during 21.4% and 13.3% of the years, with a mean 0.06 stems/m^2 density and a mean 0.004% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy sites of the nongrazed treatment over time (tables 7, 8, and 9).

On the sandy site of the ungrazed seasonlong treatment, Purple locoweed was present during 21.1% and 20.0% of the years that density and basal cover data were collected, with a mean 0.04 stems/m^2 density and a mean 0.004% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Purple locoweed was present during 26.7% and 33.3% of the years, with a mean 0.05 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the sandy site of the grazed seasonlong treatment, Purple locoweed was present during 47.4% and 32.0% of the years that density and basal cover data were collected, with a mean 0.14 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was present during 25% and 40% of the years, with a mean 0.18 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 53.3% and 40.0% of the years, with a mean 0.13 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present for the density data and basal cover increased. The percent present for the basal cover data remained the same. The stem density decreased on the sandy site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The stem density and basal cover of Purple locoweed on the sandy site of the grazed seasonlong treatment were greater than those on the sandy site of the ungrazed seasonlong treatment.

On the sandy site of the ungrazed twice-over treatment, Purple locoweed was present during 66.7% and 31.0% of the years that density and basal cover data were collected, with a mean 0.10 stems/m^2

density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was present during 66.7% and 50.0% of the years, with a mean 0.13 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 66.7% and 26.7% of the years, with a mean 0.08 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present for the density data remained the same, the percent present for the basal cover data, stem density, and basal cover decreased on the sandy site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the sandy site of the grazed twice-over treatment, Purple locoweed was present during 90.5% and 79.3% of the years that density and basal cover data were collected, with a mean 0.33 stems/m^2 density and a mean 0.04% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was present during 66.7% and 77.8% of the years, with a mean 0.27 stems/m^2 density and a mean 0.06% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 100.0% and 86.7% of the years, with a mean 0.36 stems/m^2 density and a mean 0.03% basal cover, respectively. The percent present and stem density increased and the basal cover decreased on the sandy site of the grazed twice-over treatment over time (tables 7, 8, and 9). The stem density and basal cover on Purple locoweed on the sandy site of the grazed twice-over treatment were greater than those on the sandy site of the ungrazed twice-over treatment.

On the shallow site of the nongrazed treatment, Purple locoweed was present 15.8% and 3.9% of the years that density and basal cover data were collected, with a mean 0.05 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was present during 20% and 16.7% of the years, with a mean 0.08 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 14.3%, with a mean 0.04 stems/m^2 density and was not present where basal cover data were collected. The percent present, stem density, and basal cover all decreased on the nongrazed treatment over time (tables 7, 8, and 9).

On the shallow site of the ungrazed seasonlong treatment, Purple locoweed was present during 20.0% and 7.7% of the years that density and basal cover data were collected, with a mean 0.03 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Purple locoweed was present during 26.7% and 13.3% of the years, with a mean 0.04 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed seasonlong treatment, Purple locoweed was present during 34.6% and 15.4% of the years that density and basal cover data were collected, with a mean 0.14 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was not present where the density data were collected and was present during 16.7% of the years, with a mean 0.01% basal cover. During the later period (1998-2012), Purple locoweed was present during 60.0% and 20.0% of the years, with a mean 0.19 stems/m^2 density and a mean 0.01% basal cover, respectively . The percent present and stem density increased slightly on the shallow site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The stem density and basal cover of Purple locoweed on the shallow site of the grazed seasonlong treatment were greater than those on the shallow site ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Purple locoweed was present during 86.4% and 75.9% of the years that density and basal cover data were collected, with a mean 0.76 stems/m^2 density and a mean 0.06% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple locoweed was present during 57.1% and 66.7% of the years, with a mean 0.54 stems/m^2 density and a mean 0.08% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 100.0% and 100.0% of the years, with a mean 0.85 stems/m^2 density and a mean 0.06% basal cover, respectively. The percent present and stem density decreased on the shallow site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed twice-over treatment, Purple locoweed was present during 86.4% and 86.7% of the years that density and basal cover data were collected, with a mean 1.18 stems/m^2 density and a mean 0.10% basal cover during the total 30 year period, respectively. During the early period

(1983-1992), Purple locoweed was present during 57.1% and 80.0% of the years, with a mean 0.84 stems/m^2 density and a mean 0.14% basal cover, respectively. During the later period (1998-2012), Purple locoweed was present during 100.0% and 100.0% of the years, with a mean 1.33 stems/m^2 density and a mean 0.11% basal cover, respectively. The percent present, and stem density increased and basal cover decreased on the shallow site of the grazed twice-over treatment over time (tables 7, 8, and 9). The stem density and basal cover of Purple locoweed on the shallow site of the grazed twice-over treatment were greater than those on the shallow site of the ungrazed twice-over treatment.

Purple locoweed had low stem density and basal cover on the sandy and shallow sites of the nongrazed, ungrazed and grazed seasonlong, and ungrazed and grazed twice-over treatments. Stem density and basal cover were lower on the ungrazed, ungrazed seasonlong, and ungrazed twice-over treatments than those on the grazed seasonlong and grazed twice-over treatments. Purple locoweed was not present during the drought year of 1988 on the sandy and shallow sites of the nongrazed and ungrazed and grazed seasonlong treatments and was present on the sandy and shallow sites of the ungrazed and grazed twice-over treatments.

Discussion

Purple locoweed, *Oxytropis lambertii*, is a late succession native perennial forb of the legume family, that is commonly present at low abundance on healthy mixed grass prairie plant communities. Purple locoweed can grow on sandy, shallow, silty, and clayey ecological sites. It grows better on sandy and shallow sites. Early spring aerial growth consists as a rosette o flong basal leaves with compound leaflets arising from a perennating caudex that has a stout taproot with several main roots. Purple locoweed has no stems. Several pea-shaped flowers with reddish purple petals develop on erect leafless flower stalks (scape). The mean first flower date is 26 may (1955-1962 study) with an eight week flower period from early May to late June (1969-1971 study). Erect flower stalks reached maximum height in June. The mean flower stalk heights collected during the 1955-1962 study were 18.1 cm tall, and during the 1984-1985 study were 16.8 cm tall. The mean stalk weight was 1.75 g.

Purple locoweed has low abundance, with a mean 0.13 stems/m^2 density and a mean 0.01% basal cover on the sandy ecological sites and with a mean 0.43 stems/m^2 density and mean 0.03% basal cover on the shallow ecological sites. Purple locoweed was not present during the growing season of 1988 on the sandy and shallow ecological sites of the nongrazed and ungrazed and grazed seasonlong treatments, however, it returned in 1989 on the nongrazed and grazed seasonlong treatments. Purple locoweed was present during 1988 and 1989 on the sandy and shallow ecological sites of the ungrazed and grazed twice-over treatments at slightly reduced abundance than what it was during 1987. Purple locoweed has a thick branched perennating crown with a stout taproot and main roots that can descend 3.0 to 3.7 m (10-12 ft) in loose soil and absorb water the entire length that help this plant survive the conditions on the mixed grass prairie.

Acknowledgment

I am grateful to Sheri Schneider for assistance in the production of this manuscript and for development of the tables.

Table 1. First flower and flower period of Oxytropis lambertii, Purple locoweed.

	Apr	May		Jun		Jul	Aug	Sep
First Flower								
1955-1962								
Earliest		1						
Mean			26					
Flower Period								
1969-1971		XX	XX	XX	XX			

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

Table 2. Autecology of Oxytropis lambertii, Purple locoweed, 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	10.0	31.0	18.1	40.0	65.9	100.0			

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Oxytropis lambertii, Purple locoweed, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg		29.6	46.6	44.7	37.3	58.2
Bud	14.5	8.3				
Anth	21.0	13.1	0.8			
Seed Dev	54.8	22.8	13.5	8.2		
Seed Shed	8.1	15.9	23.3	16.5	25.4	4.5
Mat	1.6	10.3	15.8	30.6	37.3	37.3
Mean Height (cm)						
Veg		2.8	5.5	4.6	4.9	4.4
Bud	22.3	9.9				
Anth	18.8	11.9	18.0			
Seed Dev	22.3	14.6	11.2	24.8		
Seed Shed	22.7	17.7	17.6	19.4	22.3	19.4
Mat	16.5	19.0	16.0	18.6	17.1	16.6
% Dryness						
Veg		1.4	16.1	5.6	10.0	10.1
Bud	11.8	7.1				
Anth	7.8	5.7	0.0			
Seed Dev	4.9	2.4	4.0	18.1		
Seed Shed	15.0	9.2	24.9	22.3	38.2	58.3
Mat	25.0	20.4	38.4	34.3	43.1	45.0
Mean Weight (g)	2.17	2.52	3.91	2.52	1.84	1.10

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 Oxytropis lambertii, Purple locoweed, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	31.1	43.4	46.8	53.0	41.1	48.8
Bud	9.8	3.8				
Anth	26.2	5.7				
Seed Dev	27.9	19.5	6.3			
Seed Shed	3.3	23.9	23.8	6.0	16.7	13.8
Mat	1.6	3.8	23.0	41.0	42.2	37.5
Mean Height (cm)						
Veg	3.3	3.5	4.8	4.7	4.3	4.0
Bud	20.9	9.8				
Anth	17.1	15.1				
Seed Dev	18.1	13.4	10.0			
Seed Shed	13.4	16.6	16.8	15.2	15.3	17.4
Mat	15.1	13.0	11.6	13.5	14.8	13.3
% Dryness						
Veg	16.1	1.4	15.5	9.2	21.5	20.5
Bud	0.7	4.5				
Anth	3.7	0.9				
Seed Dev	6.7	4.4	13.3			
Seed Shed	50.0	17.2	24.3	25.3	35.1	50.0
Mat	25.0	20.9	25.5	25.3	38.3	32.5
Mean Weight (g)	2.78	1.44	1.86	1.28	1.34	0.86

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 Oxytropis lambertii, Purple locoweed, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	25.7	20.2	39.6	36.4	39.3	13.3
Bud	14.3	2.6			1.6	
Anth	20.0	4.4				
Seed Dev	40.0	39.5	14.2	7.8	1.6	
Seed Shed		27.2	16.0	13.0	21.3	28.9
Mat		6.1	30.2	42.9	36.1	57.8
Mean Height (cm)						
Veg	5.4	3.8	4.3	3.7	4.8	4.1
Bud	16.0	9.4			13.1	
Anth	17.9	14.6				
Seed Dev	17.5	15.2	12.4	12.3	9.2	
Seed Shed		17.6	14.1	15.2	20.6	18.6
Mat		12.1	12.6	15.1	16.4	14.1
% Dryness						
Veg	5.1	11.3	15.9	11.1	11.4	9.3
Bud	3.1	17.3			2.0	
Anth	2.4	0.4				
Seed Dev	6.1	6.3	7.9	17.7	2.0	
Seed Shed		13.7	44.1	25.8	49.7	50.0
Mat		42.8	36.4	40.2	58.7	73.5
Mean Weight (g)	1.74	-	2.84	1.47	1.53	1.15

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 Oxytropis lambertii, Purple locoweed, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	25.0	21.2	34.9	29.1	30.0	26.0
Bud	16.7	7.1				
Anth	27.8	18.8				
Seed Dev	25.0	30.6	9.6			
Seed Shed	2.8	21.2	21.7	5.5	18.0	14.0
Mat	2.8	1.2	33.7	65.5	52.0	60.0
Mean Height (cm)						
Veg	7.0	2.9	3.8	4.3	4.2	3.1
Bud	18.1	19.4				
Anth	15.5	20.4				
Seed Dev	15.8	17.7	15.9			
Seed Shed	13.1	20.2	19.2	15.5	11.9	16.1
Mat	18.5	9.8	18.0	17.6	17.2	17.1
% Dryness						
Veg	15.0	0.5	2.0	10.1	25.4	6.7
Bud	3.2	1.3				
Anth	3.7	3.6				
Seed Dev	14.6	5.6	7.3			
Seed Shed	25.0	9.3	22.6	25.0	50.0	64.3
Mat	25.0	2.0	43.0	48.5	49.9	57.3
Mean Weight (g)	2.06	1.20	2.51	0.79	0.81	0.50

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

Table 7. Autecology of Oxytropis lambertii, Purple locoweed , 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	0.00	0.00	2.83	2.24	3.78
1988-1992	0.00	0.00	0.00	0.36	0.52
1993-1998	0.00	0.00	0.87	2.25	2.38
1999-2003	0.00	0.41	0.50	0.41	2.67
2004-2009	0.49	0.13	1.12	0.42	2.22
2010-2012	0.97	0.63	0.51	0.28	1.14
Shallow					
1983-1987	1.99	0.00	0.00	6.25	9.83
1988-1992	0.00	0.00	0.00	0.30	0.50
1993-1998	0.00	0.00	2.91	3.18	14.14
1999-2003	0.00	0.58	2.11	3.23	8.44
2004-2009	0.59	0.23	0.72	3.11	4.60
2010-2012	0.00	0.80	0.78	3.27	5.03
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 8. Autecology of Oxytropis lambertii, Purple locoweed, 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	0.00	0.00	0.29	0.42	0.74
1988-1992	0.00	0.00	0.10	0.10	0.14
1993-1998	0.00	0.00	0.00	0.03	0.22
1999-2003	0.04	0.06	0.19	0.03	0.31
2004-2009	0.05	0.07	0.12	0.06	0.23
2010-2012	0.00	0.05	0.00	0.07	0.17
Shallow					
1983-1987	0.00	0.00	0.28	1.12	1.63
1988-1992	0.11	0.00	0.00	0.33	0.34
1993-1998	0.00	0.00	0.00	0.08	0.31
1999-2003	0.00	0.00	0.13	0.84	1.22
2004-2009	0.00	0.04	0.08	0.46	0.86
2010-2012	0.00	0.05	0.00	0.43	0.17
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 9. Autecology of Oxytropis lambertii, Purple locoweed, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.07	0.02	0.05
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.01	0.03	0.04
1999-2003	0.00	0.01	0.01	0.01	0.05
2004-2009	0.01	0.00	0.02	0.01	0.03
2010-2012	0.01	0.01	0.00	0.01	0.01
Shallow					
1983-1987	0.04	0.00	0.00	0.12	0.19
1988-1992	0.00	0.00	0.00	0.00	0.01
1993-1998	0.00	0.00	0.01	0.11	0.23
1999-2003	0.00	0.01	0.03	0.10	0.18
2004-2009	0.01	0.00	0.01	0.08	0.10
2010-2012	0.00	0.01	0.10	0.06	0.09
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Literature Cited

Cook, C.W., and J. Stubbendieck. 1986. Range research: basic problems and techniques. Society for Range Management, Denver, CO. 317p.

Goetz, H. 1963. Growth and development of native range plants in the mixed prairie of western North Dakota. M. S. Thesis, North Dakota State University, Fargo, ND. 165p.

Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas, Lawrence, KS.

Larson, G.E., and J.R. Johnson. 2007. Plants of the Black Hills and Bear Lodge Mountains. 2nd Edition. South Dakota State University, Fargo, ND. 219p.

Manske, L.L. 2016. Autecology of prairie plants on the Northern Mixed Grass Prairie. NDSU Dickinson Research Extension Center. Range Research Report DREC 16-1093. Dickinson, ND.

Stevens, O.A. 1963. Handbook of North Dakota plants. North Dakota Institute for Regional Studies. Fargo, ND.

Stubbendieck, J., M.J. Coffin, and L.M. Landholt. 2003. Weeds of the Great Plains. Nebraska Department of Agriculture. Lincoln, NE.

Stubbendieck, J., S.L. Hatch, and N.M. Bryan. 2011. North American wildland plants. 2nd Ed. University of Nebraska Press. Lincoln, NE.

Zaczkowski, N.K. 1972. Vascular flora of Billings, Bowman, Golden Valley, and Slope Counties, North Dakota. PhD. Thesis. North Dakota State University, Fargo, ND. 219 p.