Autecology of Western Wallflower on the Northern Mixed Grass Prairie

Llewellyn L. Manske PhD
Research Professor of Range Science
North Dakota State University
Dickinson Research Extension Center
Report DREC 16-1113

The autecology of Western wallflower, *Erysimum asperum*, 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).

Western wallflower, *Erysimum asperum* (Nutt.)DC., is a member of the mustard family, Brassicaceae, and is a native, biennial (rarely perennial), dicot, herb. The first North Dakota record is Hanson 1936. First year aerial growth consists of a basal rosette oblanceolate leaves 2-10 cm (0.8-4 in) long, 0.5-1.5 mm wide, along with the early development of the crown and taproot. Second year aerial growth has a solitary, erect, stiff stem 20-80 cm (7.9-31.5 in) tall, unbranched below, widely branched at inflorescence, arising from a crown (caudex). Stem (cauline) leaves are sessile with a few teeth, linear to lanceolate or oblong, 3-8 cm (1.2-3.1 in) long. Stems and basal and stem leaves are densely covered with stiff, flattened (strigose) hairs. The root system has a taproot with numerous fibrous lateral roots. Regeneration is by limited vegetative and sexual reproduction. Vegetative growth is by sprouts from the crown. Inflorescence is numerous solitary terminal on short pedicels developing at the top of the stem, forming a dense raceme, 6-12 cm (2.4-4.7 in) long. Flowers are 1.5-2.5 cm (0.6-1.0 in) long with showy, 4 bright yellow petals appearing during late May to late July. Fruit is a slender, 4 angled pod, 6.4-12.7 cm (2.5-5 in) long, with numerous small, plump seeds with a short distal wing. Aerial parts are not usually eaten by livestock and are top killed by fire. Grazing of aerial stems by wildlife causes branching of the flower stalk. Damage to aerial parts prior to senescence activates regrowth shoots from the crown. This summary information on growth development and regeneration of Western wallflower was based on the works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Western wallflower 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 Western wallflower 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

Western wallflower 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 15 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 Western wallflower 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 Western wallflower 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

Western wallflower is a biennial; a seed germinates when conditions permit and during the first growing season a crown, taproot, and basal rosette of leaves about 10 cm (4 in) long are produced. The rosette of leaves persists through the winter and during the spring of the second growing season a single, stiff flower stalk, 20-80 cm (7.9-31.5 in) tall develops from the crown of the rosette. The earliest first flowers appeared 13 May, the mean first flowers occurred on 1 June on the fall grazed pasture of the 1955-1962 study, and the flower period, from the 1969-1971 study, was from late May to mid July (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature height of 28.5 cm (11.2 in) with an annual variance in height from 19.0 cm (7.5 in) to 36.0 cm (14.2 in) was reached during July (table 2) (Goetz 1963). The reported normal mature flower stalk height ranged from 20 cm to 80 cm (7.9-31.5 in), the range of mature stalk heights of 19.0 to 36.0 cm (7.5-14.2 in) was 95% to 45.0% of the reported normal heights, respectively. These lower stalk heights of Western wallflower on the 1955-1962 study were not caused directly by grazing effects but were caused by low levels of available mineral nitrogen below the threshold quantities of 100 lbs/ac in the soil.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 2,261 Western wallflower stems were sampled during this study with, 658 stems (29.10%) from the sandy sites, 670 stems (29.63%) from the shallow sites, 606 stems (26.80%) from the silty sites, and 327 stems (14.46%) from the clayey sites. Western wallflower can grow on the sandy, shallow, silty, and clayey ecological sites, however, it was not very abundant on any of the sites; it was more plentiful on the shallow and sandy sites than on the silty and clayey sites.

During the growing season, a mean of 22.5% of the Western wallflower plants were in the vegetative rosette stages with, 23.2% on the sandy sites, 23.8% on the shallow sites, 20.9% on the silty sites, and 22.2% on the clayey sites (tables 3, 4, 5, and 6). The data did not distinguish between the second year rosettes and the first year rosettes, however, it does appear that most of the vegetative rosettes before mid July were destine to produce a flower stalk and that the vegetative rosettes after mid July would no longer develop flower stalks that growing season. It is feasible that some rosettes survive into the third or more growing seasons before they produce a flower stalk. A few flower stalks, about 8%, were still at the anthesis (flower) stage during late July on all four ecological sites (tables 3, 4, 5, and 6).

Mean Western wallflower stalk weights were not significantly different on the four ecological sites. Stalk weights were heaviest on the clayey and shallow sites at 0.67 g and 0.64 g, respectively, and were lightest on the silty and sandy sites at 0.54 g and 0.53 g, respectively (tables 3, 4, 5, and 6).

The mean mature flower stalk heights reached during July on the 1984-1985 study were, 17.7 cm on the shallow sites, 19.2 cm on the sandy sites, 19.3 cm on the silty sites, and 21.8 cm on the clayey sites (tables 3, 4, 5, and 6). These mature flower stalk heights were all at the short end of the reported range of normal heights at 20-80 cm (7.9-31.5 in) for the Northern Plains. The lower flower stalk heights of Western wallflower on the 1984-1985 study were caused by low available mineral nitrogen below the threshold quantity of 100 lbs/ac that resulted from the traditional management practices conducted prior to the start of the study.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Patterns of the changes in individual plant species abundance were followed for 30 growing seasons during the 1983-2012 study. The number of documented Western wallflower stems on the sandy and silty ecological sites of the three management treatments were insufficient to describe abundance patterns and were not included in this report.

On the shallow site of the nongrazed treatment, Western wallflower was present during 36.8% and 19.2% of the years that density and basal cover data were collected, with a mean 0.35 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Western wallflower was present during 40.0% and 33.3% of the years, with a mean 0.20 stems/m^2 density and a mean 0.08% basal cover. During the later period (1998-2012), Western wallflower was present during 35.7% and 20.0% of the years, with a mean 0.40 stems/m^2 density and a mean 0.01% basal cover, respectively. Stem density increased and basal cover decreased on the shallow sites of the nongrazed treatment over time (tables 7, 8, and 9).

On the shallow sites of the seasonlong treatment, Western wallflower was present on the ungrazed shallow site during 50.0% and 15.4% of the years, with a mean 0.55 stems/m^2 density and a mean 0.02% basal cover, and was present on the grazed shallow site during 60.0% and 3.8% of the years that density and basal cover data were collected, with a mean 0.38 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Western wallflower was present on the ungrazed shallow site during 20.0% and 0.0 % of the years, with a mean 0.58 stems/m^2 density. During the later period (1998-2012), Western wallflower was present on the ungrazed shallow site during 60.0% and 26.7% of the years, with a mean 0.54 stems/m^2 density and a mean

0.03% basal cover, respectively. Stem density decreased slightly and basal cover increased on the ungrazed shallow site of the seasonlong treatment over time. During the early period (1983-1992), Western wallflower was present on the grazed shallow site during 20.0% and 0.0% of the years, with a mean 0.58 stems/m^2 density. During the later period (1998-2012), Western wallflower was present on the grazed shallow site during 73.3% and 6.7% of the years, with a mean 0.31 stems/m^2 density and a mean 0.002% basal cover, respectively. Stem density decreased and basal cover increased on the grazed shallow site of the seasonlong treatment over time. Western wallflower was present on the ungrazed and grazed shallow sites of the seasonlong treatment before 1988, the drought year. It had zero presence during the low precipitation period of 1988-1992. Then during the later period (1998-2012), Western wallflower returned to the ungrazed and grazed shallow sites of the seasonlong treatment at lower stem densities and at low percent basal cover (tables 7, 8, and 9).

On the shallow sites of the twice-over treatment, Western wallflower was present on the ungrazed shallow site during 63.6% and 31.0% of the years, with a mean 0.29 stems/m^2 density and a mean 0.007% basal cover, and was present on the grazed shallow site during 72.7% and 30.0% of the years that density and basal cover data were collected, with a mean 0.25 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Western wallflower was present on the ungrazed shallow site during 42.9% and 33.3% of the years, with a mean 0.44 stems/m^2 density and a mean 0.01% basal cover. During the later period (1998-2012), Western wallflower was present on the ungrazed shallow site during 73.3% and 26.7% of the years, with a mean 0.22 stems/m^2 density and a mean 0.005% basal cover, respectively. Both stem density and basal cover decreased on the ungrazed shallow site of the twice-over treatments over time. During the early period (1983-1992), Western wallflower was present on the grazed shallow site during 42.9% and 40.0% of the years, with a mean 0.37 stems/m^2 density and a mean 0.02% basal cover. During the later period (1998-2012), Western wallflower was present on the grazed shallow site during 86.7% and 33.3% of the years, with a mean 0.20 stems/m^2 density and a mean 0.007% basal cover, respectively. Both stem density and basal cover decreased on the grazed shallow site of the twice-over treatment over time. Western wallflower was present on the ungrazed and grazed shallow sites of the twice-over treatment before 1988, the drought year. It had zero presence during the low precipitation period of 1988 to 1992. Then during the later period (1998-2012), Western wallflower returned to the ungrazed and grazed shallow sites of the twice-over treatment at lower stem densities and basal cover. The ungrazed shallow site had slightly greater stem density and basal cover during the early period and later period than those on the grazed shallow site of the twice-over treatment.

Discussion

Western Wallflower, *Erysimum asperum*, is a showy biennial mustard that is commonly present at low abundance on healthy mixed grass prairie plant communities. Western wallflower can grow on sandy, shallow, silty, and clayey ecological sites at low abundance, however, it does grow better on the shallow ecological sites. First growing season aerial growth is a rosette of relatively large basal leaves that arise from a crown (caudex) with a taproot. Second growing season aerial growth is a solitary flower stalk with a relatively large raceme inflorescence of numerous attractive yellow flowers with a mean first flower date on 1 June (1955-1962 study), with a seven week flower period from late May to mid July (1969-1971 study), and with an eight week flower period extending through the third week of July (1984-1985 study). Erect aerial stems reached maximum mature flower stalk height during July. The mean mature flower stalk heights collected during the 1955-1962 study were 28.5 cm tall, and during the 1984-1985 study were 19.5 cm tall. These collected mean flower stalk heights were at the short end of the reported range of normal Northern Plains mature stalk heights at 20 cm to 80 cm tall. These shorter stalk heights occurred because the soils of both studies had mineral nitrogen available at less than the threshold quantity of 100 lbs/ac which resulted from the detrimental effects caused by the traditional management practices on the ecosystem biogeochemcial processes and soil microorganism biomass of the prairie plant communities. During the 1984-1985 study, a mean of about 81.5% of the second growing season rosettes produced a flower stalk that progressed through the phenological growth stages. Some Western wallflower rosettes may live longer than two growing seasons. Western wallflower is usually not eaten by livestock and thus the effects from partial defoliation by grazing do not directly cause annual changes in stem abundance. A quantity of soil water and a small space with reduced competition from grass plants for obtaining essential elements from the soil is required for Western wallflower seeds to germinate, produce a rosette of basal leaves, crown, and taproot during the first growing season, and then to produce a flower stalk resulting in viable seeds during the second growing season. Western wallflower was present on the three management treatments during 1984-1987 at a low mean of less than 0.5 stems/m^2 density. During the drought growing season of 1988, all of the Western wallflower plants were eliminated except for a small quantity of 0.02% basal cover survived during 1988 on the grazed shallow site of the twice-over treatment. On the nongrazed shallow site a small quantity of Western wallflower plants were present during 1989 and 1990 and then were not present for 15 growing seasons from 1991 through 2005. On the ungrazed and grazed shallow sites of the seasonlong and twice-over treatments, Western wallflower was not present during 10 growing seasons from 1989 to 1998. Grass plants recovered after 1988 relatively quickly and were strong competition for belowground essential elements. Western wallflower plants returned in 1999, but remained at relatively low abundance at less than 0.25 stems/m^2 density on the grazed shallow site of the seasonlong treatment and on the ungrazed and grazed shallow sites of the twice-over treatment. During the later period (1999-2012), Western wallflower abundance returned near to the pre-1988 levels of 0.50 stems/m^2 density on the shallow sites of the nongrazed treatment and the ungrazed site of the seasonlong treatment.

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 Erysimum asperum, Western Wallflower.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		13				
Mean			1			
Flower Period						
1969-1971		X	XX XX	XX		

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

Table 2. Autecology of Erysimum asperum, Western Wallflower, 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	19.0	36.0	28.5	18.9	24.7	92.7	100.0		

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Erysimum asperum, Western wallflower, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	32.8	35.3	19.0	12.7	25.0	23.8
Bud	1.6	3.0	2.9	1.0		
Anth	11.5	5.3	18.1	8.8		1.6
Seed Dev	54.1	37.6	40.0	2.9	32.6	
Seed Shed		7.5	10.5	22.5	34.8	33.3
Mat		11.3	9.5	52.0	7.6	41.3
Mean Height (cm)						
Veg	11.0	2.6	2.0	2.6	1.7	1.5
Bud	16.9	11.9	14.4	2.0		
Anth	14.6	14.9	17.0	11.2		10.9
Seed Dev	14.0	19.3	19.0	23.5	18.7	
Seed Shed		19.7	18.3	26.4	18.6	24.0
Mat		14.2	19.4	15.3	20.0	20.9
% Dryness						
Veg	1.5	3.0	0.2	10.1	2.4	12.6
Bud	0.0	14.8	2.0	2.0		
Anth	4.7	4.7	7.6	25.2		0.0
Seed Dev	14.4	23.3	25.5	25.0	64.6	
Seed Shed		8.7	52.5	100.0	84.8	85.6
Mat		14.6	47.5	62.6	98.6	97.0
Mean Weight (g)	0.58	-	0.58	0.36	0.58	0.57

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 Erysimum asperum, Western wallflower, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	13.4	22.1	25.2	32.0	17.8	22.1
Bud	3.0	2.3	0.9			
Anth	20.9	3.8	10.8	6.2		
Seed Dev	62.7	47.3	43.2	9.3	40.0	5.2
Seed Shed		11.5	9.9	14.4	32.2	28.6
Mat		13.0	9.9	38.1	10.0	44.2
Mean Height (cm)						
Veg	2.7	1.2	1.2	1.8	1.6	1.2
Bud	11.7	11.2	7.9			
Anth	16.5	12.9	17.9	18.4		
Seed Dev	21.9	20.2	17.6	15.8	17.1	23.2
Seed Shed		15.4	18.5	18.0	23.1	20.3
Mat		15.7	13.8	19.3	22.2	17.4
% Dryness						
Veg	3.0	0.2	0.3	8.1	15.1	17.1
Bud	1.0	0.7	2.0			
Anth	4.3	0.4	4.1	17.4		
Seed Dev	9.9	24.8	31.4	33.3	72.4	61.5
Seed Shed		4.0	54.6	92.9	87.8	91.4
Mat		6.8	58.2	65.1	80.6	97.4
Mean Weight (g)	0.40	0.44	0.90	0.76	0.77	0.58

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 Erysimum asperum, Western wallflower, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	9.2	21.2	15.1	25.7	24.3	18.2
Bud	3.1	8.6	2.2			
Anth	32.3	10.6	20.4	2.9		
Seed Dev	55.4	33.1	48.4	11.4	30.0	5.5
Seed Shed		20.5	3.2	25.7	40.0	30.9
Mat		6.0	10.8	34.3	5.7	45.5
Mean Height (cm)						
Veg	2.3	2.8	2.0	1.5	1.8	1.6
Bud	17.3	14.7	8.5			
Anth	19.2	15.0	15.4	17.4		
Seed Dev	20.1	21.5	18.9	21.0	15.9	19.9
Seed Shed		16.2	13.8	29.1	21.3	22.6
Mat		17.5	15.3	22.8	16.4	18.6
% Dryness						
Veg	0.3	5.7	2.5	5.2	5.1	3.7
Bud	0.0	6.7	2.0			
Anth	3.3	4.9	6.4	25.0		
Seed Dev	7.3	23.1	19.3	31.5	40.2	73.4
Seed Shed		14.5	34.0	95.8	55.7	98.9
Mat		17.3	52.3	66.5	75.0	99.8
Mean Weight (g)	0.52	0.66	0.49	0.56	0.70	0.30

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 Erysimum asperum, Western wallflower, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	3.4	12.5	13.0	41.4	36.8	17.1
Bud	10.3	3.1				
Anth	10.3	7.8	14.5	13.8		
Seed Dev	75.9	51.6	60.9	3.4	36.8	2.9
Seed Shed		21.9	1.4	6.9	10.5	40.0
Mat		3.1	10.1	34.5	15.8	40.0
Mean Height (cm)						
Veg	2.4	0.9	8.8	2.2	1.8	2.5
Bud	21.8	11.0				
Anth	17.6	14.2	27.7	18.4		
Seed Dev	21.1	18.4	16.0	26.6	17.1	18.1
Seed Shed		16.2	29.1	13.1	19.6	25.5
Mat		16.2	16.1	18.1	11.6	19.8
% Dryness						
Veg	0.0	0.0	0.0	5.3	1.1	1.7
Bud	0.0	12.5				
Anth	0.7	1.2	6.4	25.5		
Seed Dev	10.4	10.8	35.9	25.0	74.4	50.0
Seed Shed		3.5	2.0	51.0	87.5	90.1
Mat		2.0	46.4	42.7	100.0	95.8
Mean Weight (g)	0.56	0.70	0.66	0.84	0.41	0.83

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

Table 7. Autecology of Erysimum asperum, Western wallflower, 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	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	3.98	0.00	14.48	4.89	4.93
1988-1992	0.47	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	1.47	0.66	1.02
2004-2009	1.66	3.48	1.03	1.59	0.96
2010-2012	7.64	10.22	7.18	1.81	2.24
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 8. Autecology of Erysimum asperum, Western wallflower, 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	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	0.00	0.00	0.00	0.16	0.26
1988-1992	1.01	0.00	0.00	0.00	0.04
1993-1998	0.00	0.00	0.00	0.03	0.00
1999-2003	0.00	0.00	0.00	0.05	0.00
2004-2009	0.04	0.14	0.00	0.04	0.10
2010-2012	0.53	1.26	0.08	0.03	0.08
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 9. Autecology of Erysimum asperum, Western wallflower, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	0.08	0.00	0.29	0.10	0.09
1988-1992	0.01	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.02	0.01	0.02
2004-2009	0.02	0.05	0.02	0.03	0.02
2010-2012	0.15	0.16	0.09	0.03	0.04
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. South Dakota State University. B 732 (2nd ed.). Brookings, SD.

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.

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.