Autecology of Slim rockcress on the Northern Mixed Grass Prairie

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Report DREC 17-1128

The autecology of Slim rockcress, *Arabis holboellii*, 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).

Slim rockcress, *Arabis holboellii* Hornem., is a member of the mustard family, Brassicaceae, and is a native, biennial (rarely perennial), dicot, herb. The first North Dakota record is Waldron 1904. First year aerial growth consists of a basal rosette of linear-oblanceolate to broadly spatulate leaves, 1-5 cm (0.4-2.0 in) long, 1.5-6 mm wide, along with the early development of the crown and taproot. Second year aerial growth has a solitary (rarely a few) erect, simple (rarely branched above) stem, 30-60 cm (11.8-23.6 in) tall arising from a branching caudex. Stem (cauline) leaves are clasping, entire, lanceolate to oblong, 1-4 cm (0.4-1.6 in) long, 1.5-6 mm wide. Stems and basal and stem leaves are densely pubescent with fine to coarse trichomes. The root system has a taproot with numerous fibrous lateral roots and tufts of fibrous roots develop when additional stems develop from the caudex branches. Regeneration is by limited vegetative and sexual reproduction. Vegetative growth is by sprouts from the caudex or caudex branches. Inflorescence is numerous solitary flowers terminal on short pedicels developing along the upper portion of the stem, forming a loose raceme. Flowers are small, 5-10 mm long, 2-3.5 mm wide with purplish pink to white corolla, appearing during late May to late June. Fruit is a flattened pod 2-2.5 mm wide that hangs down with tiny seeds that have a narrow wing all around. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial parts prior to senescence activates regrowth shoots from the caudex and caudex branches. This summary information on growth development and regeneration of slim rockcress was based on works of Stevens 1963, Zaczkowski 1972, and Great Plains Flora Association 1986.

Procedures

The 1955-1962 Study

Slim rockcress 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 Slim rockcress 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 1983-2012 Study

A long-term study on change in abundance of Slim rockcress 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 Slim rockcress 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 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 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

Slim rockcress is a native, biennial, dicot, herb. The first year aerial growth consists of a rosette of basal leaves and development of the crown and taproot. The second year aerial growth resumes extremely early in the spring consisting of a solitary erect simple stem. Along the upper portion of the stem, numerous small solitary flowers with pink to white corollas are terminal on short pedicels. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 7 May, the mean first flowers occurred on 24 May, and the 4 week flower period extending from the last week of May through the third week of June was observed during the 1969-1971 study (table 1) (Goetz 1963, Zaczkowski 1972). The combined flower dates from the 1955-1962 and 1969-1971 study extends the flower period to 6 weeks, from the start of the second week of May through the third week of June. A mean mature stem height of 51.4 cm (20.2 in) with an annual variance in height from 35.0 cm (13.8 in) to 60.0 cm (23.6 in) was reached during June (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 30 cm to 60 cm (11-8-23.6 in) tall. The mean mature stem heights measured during the 1955-1961 study were within the normal range in height for the Northern Plains.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Slim rockcress had low abundance on silty ecological sites. Patterns in the changes in individual plant species 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, Slim rockcress was present during 38.9% and 8.0% of the years that density and basal cover data were collected, with a mean 0.23 stems/m^2 density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Slim rockcress was present during 50.0% and 13.3% of the years with a mean 0.30 stems/m^2 density and a mean 0.005% basal cover, respectively. Slim rockcress was not present during the early period and all observations were made during the later period (tables 3, 4, and 5).

On the sandy site of the ungrazed seasonlong treatment, Slim rockcress was present during 36.8% and 12.0% of the years that density and basal cover data were collected with a mean 0.11 stems/m^2 density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Slim rockcress was present during 50.0% and 13.3% of the years with a mean 0.13 stems/m^2 density and a mean 0.005% basal cover, respectively. Slim rockcress was not present during the early period and all observations were made during the later period (tables 3, 4, and 5).

On the sandy site of the grazed seasonlong treatment, Slim rockcress was present during 57.9% and 12.0% of the years that density and basal cover data were collected with a mean 0.12 stems/m^2 density and a mean 0.005% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was not present on the sandy site of the grazed seasonlong treatment. During the later period (1998-2012), Slim rockcress was present during 73.3% and 13.3% of the years with a mean 0.15 stems/m^2 density and a mean 0.004% basal cover, respectively. Slim rockcress was not present during the early period and all observations were made during the later period (tables 3, 4, and 5). The percent present, stem density, and basal cover were similar on the sandy sites of the ungrazed and grazed seasonlong treatments.

On the sandy site of the ungrazed twice-over treatment, Slim rockcress was present during 76.2% and 44.8% of the years that density and basal cover data were collected with a mean 0.41 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was present during 76.2% and 44.8% of the years with a mean 0.07 stems/m^2 density and a mean 0.006% basal cover, respectively. During the later period (1998-2012), Slim rockcress was present during 100.0% and 80.0% of the years with a mean 0.54 stems/m^2 density and a mean 0.06% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the sandy site of the grazed twice-over treatment, Slim rockcress was present during 81.0% and 31.0% of the years that density and basal cover data were collected with a mean 0.43 stems/m^2 density and a mean 0.009% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was present during 33.3% and 11.1% of the years with a mean 0.08 stems/m^2 density and a mean 0.005% basal cover, respectively. During the later period (1998-2012), Slim rockcress was present during 100.0% and 53.3% of the years with a mean 0.57 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 grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were similar on the sandy site of the ungrazed and grazed twice-over treatments.

On the shallow site of the nongrazed treatment, Slim rockcress was present during 47.7% and 19.2% of the years that density and basal cover data were collected with a mean 0.25 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was not present where density data were collected and was present during 16.7% of the years with a mean 0.008% basal cover. During the later period (1998-2012), Slim rockcress was present during 64.3% and 20.0% of the years with a mean 0.34 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the nongrazed treatment over time (tables 3, 4, and 5).

On the shallow site of the ungrazed seasonlong treatment, Slim rockcress was present during 15.0% and 7.7% 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), Slim rockcress was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Slim rockcress was present during 20.0% and 13.3% of the years with a mean 0.06 stems/m^2 density and a mean 0.003% basal cover, respectively. Slim rockcress was not present during the early period and all observations were made during the later period (tables 3, 4, and 5).

On the shallow site of the grazed seasonlong treatment, Slim rockcress was present during 60.0% and 7.7% of the years that density and basal cover data were collected with a mean 0.27 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was not present where basal cover data were collected and was present during 20.0% of the years with a mean 0.10 stems/m^2 density. During the later period (1998-2012), Slim rockcress was present during 73.3% and 13.3% of the years with a mean 0.33 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 grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present for the basal cover data, and basal cover were similar on the shallow sites of the ungrazed and grazed seasonlong treatments. The percent present for the density data and stem density were greater on the shallow site of the grazed seasonlong treatment than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Slim rockcress was present during 72.7% and 27.6% of the years that density and basal cover data were collected with a mean 0.35 stems/m^2 density and a mean 0.10% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was present during 42.9% and 22.2% of the years with a mean 0.10 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Slim rockcress was present during 86.7% and 40.0% of the years with a mean 0.47 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present for the density data and stem density increased, and percent present for the basal cover data and basal cover remained the same on the shallow site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the shallow site of the grazed twice-over treatment, Slim rockcress was present during 72.7% and 26.7% of the years that density and basal cover data were collected with a mean 0.17 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Slim rockcress was present during 28.6% and 20.0% of the years with a mean 0.07 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Slim rockcress was present during 93.3% and 40.0% of the years with a mean 0.21 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present and stem density increased and basal cover remained the same on the shallow site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present for the density data, the percent present for the basal cover data, and basal cover were similar on the shallow sites of the ungrazed and grazed twice-over treatments. The stem density was greater on the shallow site of the ungrazed twice-over treatment than that on the shallow site of the grazed twice-over treatment.

On the sandy sites, Slim rockcress was present during 58.2% and 21.6% of the years that density and basal cover data were collected with a mean 0.26 stems/m^2 density and a mean 0.01% basal cover, respectively. On the shallow sites, Slim rockcress was present during 53.6% and 17.8% of the years that density and basal cover data were collected with a mean 0.22 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present, stem density, and basal cover were similar on the sandy and shallow sites.

Discussion

Slim rockcress, *Arabis holboellii*, is a native, late succession, biennial, forb of the mustard family that is commonly present at low to moderate abundance on healthy mixed grass prairie plant communities. Slim rockcress can grow on sandy and shallow ecological sites at about equal abundance. The first year aerial growth consists of a rosette of basal leaves along with a crown and taproot. The second year aerial growth consists of an erect stem that can grow to 60 cm (24 in) tall. Small solitary flowers develop along the upper portion of the stem in ascending order and the resulting flattened seed pods hang downward. The earliest first flowers appeared 7 May, the mean first flowers occurred on 24 May (1955-1962 study), with an observed 4 week flower period (1969-1971 study), and a combined flower period of 6 weeks from the start of the second week of May through the third week of June. The tall

mean mature stem height of 51.4 cm (20.2 in) was reached in June (1955-1962 study). Slim rockcress has similar abundance on sandy and shallow ecological sites. Slim rockcress is present on the sandy sites during 58.2% and 21.6% of the years with a mean 0.26 stems/m^2 density and a mean 0.01% basal cover and it is present on the shallow sites during 53.6% and 17.8% of the years with a mean 0.22 stems/m^2 density and a mean 0.01% basal cover.

The production of a high number of tiny seeds, an overwintering rosette of basal leaves, vegetative sprouts from a branching caudex, and continuous development of the taproot and fibrous lateral root system help Slim rockcress to persist through the harsh conditions of the Northern 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 Arabis holboellii, Slim rockcress.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		7				
Mean		24				
Flower Period						
1969-1971		X	XX X			

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

Table 2. Autecology of Arabis holboellii, Slim rockcress, 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	35.0	60.0	51.4	8.0	67.8	100.0			

Data from Goetz 1963.

Table 3. Autecology of Arabis holboellii, Slim rockcress, 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	0.00	0.82	1.26
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	1.74	4.13
1999-2003	1.33	0.52	0.63	3.45	4.36
2004-2009	0.32	1.24	1.16	2.08	3.40
2010-2012	5.10	0.28	0.33	3.14	2.71
Shallow					
1983-1987	0.00	0.00	4.05	1.21	0.58
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	1.51	0.00	2.54	2.18	2.90
1999-2003	1.69	0.00	5.85	2.96	1.16
2004-2009	1.57	1.01	1.56	1.84	1.31
2010-2012	0.78	0.00	0.36	2.43	1.34
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 4. Autecology of Arabis holboellii, Slim rockcress, 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	0.00	0.11	0.07
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.08	0.00	0.00
1999-2003	0.10	0.03	0.06	0.90	0.13
2004-2009	0.00	0.07	0.05	0.72	0.14
2010-2012	0.07	0.00	0.00	0.55	0.04
Shallow					
1983-1987	0.46	0.00	0.00	0.16	0.06
1988-1992	0.00	0.00	0.00	0.00	0.04
1993-1998	0.07	0.00	0.00	0.00	0.00
1999-2003	0.55	0.03	0.09	0.15	0.04
2004-2009	0.00	0.02	0.00	0.14	0.06
2010-2012	0.00	0.00	0.00	0.02	0.00
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 5. Autecology of Arabis holboellii, Slim rockcress, 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	0.00	0.01	0.02
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.03	0.05
1999-2003	0.03	0.05	0.02	0.08	0.09
2004-2009	0.01	0.02	0.02	0.03	0.05
2010-2012	0.09	0.00	0.00	0.05	0.04
Shallow					
1983-1987	0.00	0.00	0.05	0.03	0.02
1988-1992	0.00	0.00	0.00	0.00	0.00
.031993-1998	0.02	0.00	0.03	0.03	0.03
1999-2003	0.07	0.00	0.06	0.08	0.02
2004-2009	0.03	0.02	0.02	0.04	0.02
2010-2012	0.01	0.00	0.00	0.02	0.02
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

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