Autecology of Prairie Cinquefoil on the Northern Mixed Grass Prairie

Llewellyn L. Manske PhD
Research Professor of Range Science
North Dakota State University
Dickinson Research Extension Center
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The autecology of Prairie cinquefoil, *Potentilla pensylvanica*, 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).

Prairie cinquefoil, *Potentilla pensylvanica* L., is a member of the rose family, Rosaceae, and is a native, perennial, dicot, herb that does not occur in Pennsylvania. The first North Dakota record is Bergman 1910. Early aerial growth consists of a basal rosette of long petioled leaves 4-20 cm (1.6-7.9 in) long, deeply odd pinnately divided into 5 to 7 leaflets. Annual aerial growth has one to several, erect, ascending, or spreading at base stems, 20-40 cm (7.9-15.7 in) tall, arising from a slender to stout perennating branched crown (caudex). Stem (cauline) leaves are 4-9 cm (1.6-3.5 in) long with short petiole below, sessile above, reducing upward. Stems are densely pubescent with soft hairs, and leaves are densely pubescent with silvery hairs below, smooth above. The root system has a taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the crown. Inflorescence has 3 to 40 flowers densely clustered into a compact cyme. Flower has 5 pale to bright yellow petals appearing during mid June to mid July. Fruit is an achene of 1 seed. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown. This summary information on growth development and regeneration of prairie cinquefoil was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Prairie cinquefoil 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 Prairie cinquefoil 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 Prairie cinquefoil 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 Prairie cinquefoil 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

Prairie cinquefoil resumes annual aerial growth early with a basal rosette of leaves with long petioles that extend to 4-20 cm (1.6-7.9 in) long. One to several erect base stems arise from a slender to stout perennating branched caudex. Stems are densely pubescent with soft hairs. A taproot with numerous fibrous lateral roots descends from the caudex. Three to 40 flowers with 5 pale to bright yellow petals are densely clustered into a compact cyme. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 21 June, the mean first flowers occurred on 5 July, with a 6 week long flower period from mid June to the end of July (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 19.8 cm (7.8 in) with an annual variance in height from 5.0 cm (2.0 in) to 29.0 cm (11.4 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20.0 cm to 40.0 cm (7.9-15.7 in) tall. The mature stem heights measured during the 1955-1962 study were within the short end or shorter than the normal stem height for the Northern Plains.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Prairie cinquefoil was found to have low abundance on sandy and shallow ecological sites. Patterns in the changes of individual plant species abundance was followed for 30 growing seasons during the 1983-2012 study on the silty ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 3, 4, and 5).

On the silty site of the nongrazed treatment, Prairie cinquefoil was present during 15.8% and

15.4% of the years that density and basal cover data were collected with a mean 0.03 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Prairie cinquefoil 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), Prairie cinquefoil was present during 21.4% and 20.0% of the years with a mean 0.04 stems/m^2 density and a mean 0.007% basal cover, respectively. Prairie cinquefoil was not present with the density data during the early period and all density observations were made during the later period that indicated low abundance. The percent present for basal cover data increased slightly and basal cover decreased slightly on the silty site of the nongrazed treatment over time (tables 3, 4, and 5).

On the silty site of the ungrazed seasonlong treatment, Prairie cinquefoil was present during 40.0% and 15.4% of the years that density and basal cover data were collected with a mean 0.09 stems/m^2 density and a mean 0.007% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Prairie cinquefoil was present during 20.0% and 16.7% of the years with a mean 0.18 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), Prairie cinquefoil was present during 46.7% and 20.0% of the years with a mean 0.06 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present increased slightly and stem density and basal cover decreased on the silty site of the ungrazed seasonlong treatment over time (tables 3, 4, and 5).

On the silty site of the grazed seasonlong treatment, Prairie cinquefoil was present during 15.0% and 3.9% of the years that density and basal cover data were collected with a mean 0.09 stems/m^2 density and a mean 0.005% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Prairie cinquefoil was present during 20.0% and 16.7% of the years with a mean 0.30 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Prairie cinquefoil was present during 13.3% and 0.0% of the years, with a mean 0.013 stems/m^2 density and a mean 0.0% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the silty site of the grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were slightly greater on the silty site of the ungrazed seasonlong treatment than those on the silty site of the grazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, Prairie cinquefoil was present during 68.2% and 44.8% of the years that density and basal cover data were collected with a mean 0.52 stems/m^2 density and a mean 0.053% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Prairie cinquefoil was present 57.1% and 55.6% of the years with a mean 1.30 stems/m^2 density and a mean 0.16% basal cover, respectively. During the later period (1998-2012), Prairie cinquefoil was present during 73.3% and 53.3% of the years with a mean 0.16 stems/m^2 density and a mean 0.008% basal cover, respectively. The percent present for density data increased, percent present for basal cover data decreased slightly, and stem density and basal cover decreased greatly on the silty site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the silty site of the grazed twice-over treatment, Prairie cinquefoil was present during 72.7% and 46.7% of the years that density and basal cover data were collected with a mean 0.65 stems/m^2 density and a mean 0.065% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Prairie cinquefoil was present during 57.1% and 60.0% of the years with a mean 1.43 stems/m^2 density and a mean 0.17% basal cover, respectively. During the later period (1998-2012), Prairie cinquefoil was present during 80.0% and 53.3% of the years with a mean 0.29 stems/m^2 density and a mean 0.019% basal cover, respectively. The percent present for density data increased, percent present for basal cover data decreased slightly, and stem density and basal cover decreased greatly on the silty site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were fairly similar on the silty site of the ungrazed and grazed twice-over treatments.

On the silty site, Prairie cinquefoil was present during 42.3% and 25.2% of the years with a mean 0.28 stems/m^2 density and a mean 0.03% basal cover. Prairie cinquefoil has a fairly low abundance on the silty site.

On the silty site of the nongrazed treatment, Prairie cinquefoil was present during 15.8% and 15.4% of the years with a mean 0.03 stems/m^2 density and a mean 0.006% basal cover. On the silty site of the seasonlong treatment, Prairie cinquefoil was present during 27.5% and 9.6% of the years with a

mean 0.09 stems/m^2 density and a mean 0.006% basal cover. On the silty site of the twice-over treatment, Prairie cinquefoil was present during 70.5% and 45.8% of the years with a mean 0.59 stems/m^2 density and a mean 0.06% basal cover. The percent present, stem density, and basal cover were all greater on the silty site of the twice-over treatment.

During the drought growing season of 1988; Prairie cinquefoil was not present on the nongrazed and seasonlong treatments; Prairie cinquefoil was present on the twice-over treatment 4 times out of a possible 4 for an index of 100.0%. Prairie cinquefoil has good drought tolerance on the twice-over treatment. During the period of 1989 to 1992, Prairie cinquefoil was not present on any management treatment which would indicate that drought conditions caused some problems for Prairie cinquefoil to be absent for a long period following a drought growing season.

Discussion

Prairie cinquefoil, *Potentilla pensylvanica*, is a native, late succession, perennial, dicot, forb of the rose family that is commonly present on healthy mixed grass prairie plant communities. Prairie cinquefoil grows well on silty ecological sites and grows better on silty sites managed with the twice-over rotation system. Annual aerial growth begins with a basal rosette of leaves with long petioles, followed by a single to several upright stems arising from a perennating branched caudex. Several flowers form a dense compact cyme at the upper portion of the stem. The mean first flower occurred on 5 July (1955-1962 study), with a 6 week long flower period from mid June to the end of July (1969-1971 study). The mean mature stem height of 19.8 cm (7.8 in) is reached during July (1955-1962 study). Prairie cinquefoil does not and has not grown in Pennsylvania.

The perennating caudex that has short branches and the taproot help Prairie cinquefoil to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Potentilla pensylvanica, Prairie cinquefoil.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest			21			
Mean				5		
Flower Period						
1969-1971			XX	XX XX		

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

Table 2. Autecology of Potentilla pensylvanica, Prairie cinquefoil, 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	5.0	29.0	19.8	10.3	42.1	70.3	100.0		

Data from Goetz 1963.

Table 3. Autecology of Potilla pensylvanica, Potentilla or Cinquefoil, 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	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	0.00	3.38	7.78	9.19	10.11
1988-1992	0.00	0.00	0.00	0.37	0.17
1993-1998	0.00	1.04	0.00	0.00	3.28
1999-2003	0.00	0.25	0.23	1.98	4.19
2004-2009	0.40	0.40	0.00	1.83	0.81
2010-2012	0.39	0.24	0.00	0.51	0.85

Table 4. Autecology of Potentilla pensylvanica, Potentilla or Cinquefoil, 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	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	0.47	0.88	0.98	2.10	1.95
1988-1992	0.00	0.00	0.00	0.08	0.20
1993-1998	0.00	0.00	0.00	0.01	0.04
1999-2003	0.23	0.05	0.00	0.13	0.21
2004-2009	0.00	0.04	0.00	0.09	0.13
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 5. Autecology of Potilla pensylvanica, Potentilla or Cinquefoil, 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	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	0.00	0.09	0.15	0.30	0.33
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.01	0.00	0.00	0.03
1999-2003	0.00	0.01	0.01	0.03	0.05
2004-2009	0.01	0.01	0.00	0.02	0.01
2010-2012	0.01	0.00	0.00	0.00	0.01

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.

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.