Autecology of Purple Prairie Clover 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 17-1137

The autecology of Purple prairie clover, *Dalea purpurea*, 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 prairie clover, *Dalea purpurea* Vent., is a member of the legume (bean, pea) family, Fabaceae, syn.: *Petalostemum purpureum* Vent., and is a native, perennial, warm season, dicot, herb that is moderately drought tolerant, and fairly shade tolerant. The first North Dakota record is Bolley 1891. Annual aerial growth has 1 to 3, sometimes several, erect or ascending stems 20-60 cm (8-24 in) tall arsing from a subterranian woody crown (caudex) 2-12 cm (1-5 in) thick with several lateral branches 3-7 cm (1-3 in) long. Stem (cauline) leaves are alternate odd pinnately compound 1-4 cm (0.4-1.6 in) long with linear, oblanceolate, or elliptic leaflets 5-25 mm long and 0.5-1.5 mm wide. The coarse nonfibrous root system has one woody taproot 6-10 mm in diameter that can descend 1.8 to 2.4 m (6-8 ft) in depth and has 3 to 7 orange-brown colored lateral roots arising from the top 10 cm (4 in) extending horizontally for 45 cm (18 in) before turning downward for 1.4 m (4.5 ft). These roots have little or no absorption in top 30 cm (12 in) of soil. Plant survival is highly dependent upon mycorrhizal fungi for uptake and transport of soil nutrients. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the thick crown and by sprouts from the short lateral subsurface crown branches. Inflorescence are terminal dense cylindrical spikes 5 cm (2 in) long on top of stem branches. Flowers are tiny perfect, pea shaped with 5 purple to rose petals. Blooms start a bottom row and progressively move upward during late June to early August. Pollination is by bumblebees, beetles, and other insects. Fruits are a one seeded legume pod. Aerial parts are eaten by livestock and are totally consumed by fire. The buds on the large subterranean root crown usually survive burning and the large woody taproot stores photosynthate and nutrients that can support post defoliation sprouting and regrowth. This summary information on growth development and regeneration of purple prairie clover was based on works of Weaver and Fitzpatrick 1934; Weaver 1954, 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, League 2004, Larson and Johnson 2007, Wynia 2008, and Stubbendieck et al. 2011.

Procedures

The 1955-1962 Study

Purple prairie clover 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 prairie clover 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 Purple prairie clover 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 prairie clover 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

Purple prairie clover resumes annual aerial growth with one to several erect stems arising from a subterranean woody caudex 2-12 cm (1-5 in) thick that has several lateral branches 3-7 cm (1-3 in) long. A single woody taproot 6-10 mm in diameter arises from the caudex and can descend 1.8-2.4 m (6-8 ft) in depth. Three to seven orange-brown colored lateral nonfibrous coarse roots arise from the top 10 cm (4 in) of the taproot that extend horizontally for 45 cm (18 in) turn and extend downward for 1.4 m (4.5 ft). The roots in the top 30 cm (12 in) of soil have little or no absorption and are not competitive with other plant roots in the top zone. The flowers are tiny perfect, pea shaped with 5 purple to rose petals develop on dense cylindrical spikes 5 cm (2 in) long on top of stem branches. Blooms progress upward from the bottom row. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 25 June, the mean first flowers occurred on 13 July, and the 6 week flower period extends from late June to early August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 25.8 cm (10.2 in) with an annual variance in height

from 19.0 cm (7.5 in) to 28.0 cm (11.0 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20 cm (7.9 in) to 60.0 cm (23.6 in) tall. The mature stem heights measured during the 1955-1961 study were within or just short of the bottom end of 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. Purple prairie clover was found to have low abundance on the sandy and 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 shallow ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 3, 4, and 5).

On the shallow site of the nongrazed treatment, Purple prairie clover was present during 31.6% and 7.7% of the years that density and basal cover data were collected with a mean 0.13 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 prairie clover 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), Purple prairie clover was not present where basal cover data were collected and was present during 42.9% of the years with a mean 0.17 stems/m^2 density. Purple prairie clover was not present during the early period with the density data and was not present during the later period with the basal cover data. All of the observations for the density data were made during the later period and for the basal cover data were made during the early period that indicated low abundance for both the density data and the basal cover data.

On the shallow site of the ungrazed seasonlong treatment, Purple prairie clover was present during 30.0% and 7.7% of the years that density and basal cover data were collected with a mean 0.09 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 prairie clover was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Purple prairie clover was present during 40.0% and 13.3% of the years with a mean 0.12 stems/m^2 density and a mean 0.003% basal cover, respectively. Purple prairie clover was not present during the early period and all observations were made during the later period that indicated low abundance.

On the shallow site of the grazed seasonlong treatment, Purple prairie clover was present during 45.0% and 19.2% of the years that density and basal cover data were collected with a mean 0.23 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple prairie clover was present during 80.0% and 33.3% of the years with a mean 0.54 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), Purple prairie clover was present during 33.3% and 20.0% of the years with a mean 0.12 stems/m^2 density and a mean 0.004% basal cover, respectively. The percent present for density data, percent present for basal cover data, stem density, and basal cover all decreased greatly on the shallow site of the grazed seasonlong treatment over time (tables 3, 4, and %). The percent present, stem density, and basal cover 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, Purple prairie clover was present during 90.9% and 69.0% of the years that density and basal cover data were collected with a mean 0.68 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple prairie clover was present during 85.7% and 66.7% of the years with a mean 1.23 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Purple prairie clover was present during 93.3% and 73.3% of the years with a mean 0.43 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present for density data and percent present for basal cover data increased and stem density and basal cover decreased 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, Purple prairie clover was present during 95.5% and 53.3% of the years that density and basal cover data were collected with a mean 0.64 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Purple prairie clover was present during 85.7% and 70.0% of the years with a mean 0.94 stems/m^2 density and a mean 0.04% basal cover, respectively. During the later period (1998-2012), Purple prairie clover was present during 100.0% and 46.7% of the years with a mean 0.50 stems/m^2 density and a mean 0.01% basal cover, respectively. The

percent present for the density data increased and percent present for basal cover data, and stem density, and basal cover decreased slightly on the shallow site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present for the density data, percent present for the basal cover data, stem density, and basal cover were fairly similar on the shallow sites of the ungrazed and grazed twice-over treatment.

Purple prairie clover was present on the shallow site of the nongrazed treatment during 31.6% and 7.7% of the years with a mean 0.13 stems/m^2 density and a mean 0.004% basal cover. Purple prairie clover was present on the shallow site of the seasonlong treatment during 37.5% and 13.5% of the years with a mean 0.16 stems/m^2 density and a mean 0.004% basal cover. Purple prairie clover was present on the shallow site of the twice-over treatment during 93.2% and 61.2% of the years with a mean 0.66 stems/m^2 density and a mean 0.024% basal cover. The percent present for density data, percent present for basal cover data, stem density, and basal cover were all much greater on the shallow site of the twice-over treatment than those on the shallow sites of the nongrazed and seasonlong treatments.

Purple prairie clover was not present on the shallow sites of the nongrazed and the ungrazed and grazed seasonlong treatments during the drought growing season of 1988. Purple prairie clover was present on the shallow sites of the ungrazed and grazed twice-over treatment during the drought growing season of 1988. Purple prairie clover has greater drought tolerance when managed with the twice-over rotation management treatment.

Discussion

Purple prairie clover, *Dalea purpurea*, is a native, late succession, perennial, warm season, dicot forb of the legume family that is commonly present on healthy mixed grass prairie plant communities. Purple prairie clover can grow better on shallow ecological sites and grows best on the shallow sites managed by the twice-over rotation treatment. Purple prairie clover resumes annual aerial growth with one to several erect stems arising from a thick woody caudex. A woody taproot descends 1.8-2.4 m (6-8 ft) below the caudex. Several coarse lateral roots arise from the top portion of the taproot extend horizontally before turning downward. Tiny flowers develop on dense cylindrical spikes 5 cm (2 in) long blooming from bottom upward. The mean first flower date is 13 July (1955-1962 study), with a 6 week flower period from late June to early August (1969-1971 study). A mean mature stem height of 25.8 cm (10.2 in) was reached during August (1955-1962 study). Purple prairie clover had greater percent present, stem density, and basal cover on the twice-over treatment than those on the nongrazed and seasonlong treatments. The twice-over treatment was the only management treatment that Purple prairie clover was present during the drought growing season of 1988.

The thick woody caudex with several lateral branches, the deep woody taproot, and the coarse deep lateral roots help Purple prairie clover to persist through the harsh conditions on 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 Dalea purpurea, Purple prairie clover.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest			25			
Mean				13		
Flower Period						
1969-1971			X	XX XX	X	

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

Table 2. Autecology of Dalea purpurea, Purple prairie clover, 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	28.0	25.8		19.8	64.6	99.3	100.0	

Data from Goetz 1963.

Table 3. Autecology of Dalea purpurea, Purple prairieclover, 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	0.00	0.00	3.00	7.93	5.26
1988-1992	0.00	0.00	10.80	12.51	18.48
1993-1998	0.00	0.00	6.90	3.23	1.50
1999-2003	0.35	0.00	1.46	1.51	3.00
2004-2009	2.76	1.14	1.03	1.44	1.91
2010-2012	1.40	1.10	0.00	1.27	3.20
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 4. Autecology of Dalea purpurea, Purple prairieclover, 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	0.55	0.55	0.20
1988-1992	0.11	0.00	0.10	0.32	0.35
1993-1998	0.15	0.00	0.00	0.14	0.20
1999-2003	0.00	0.05	0.05	0.26	0.07
2004-2009	0.00	0.02	0.02	0.09	0.07
2010-2012	0.00	0.00	0.00	0.02	0.02
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 5. Autecology of Dalea purpurea, Purple prairieclover, 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	0.00	0.00	0.04	0.18	0.10
1988-1992	0.00	0.00	0.05	0.08	0.09
1993-1998	0.00	0.00	0.04	0.07	0.03
1999-2003	0.01	0.00	0.01	0.05	0.07
2004-2009	0.02	0.02	0.01	0.04	0.03
2010-2012	0.02	0.01	0.00	0.02	0.06
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.

League, K. R. 2004. *Dalea purpurea*. Fire Effects Information System. USDA. Forest Service. http://www.fs.fed.us/database/feis/

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

Weaver, J.E., and T.J. Fitzpatrick. 1934. The Prairie. Ecological Monographs 4(2):109-295.

Weaver, J.E. 1954. North American Prairie. Johnson Publishing Co. Lincoln, NE.

Weaver, J.E. 1958. Classification of root systems of forbs of grasslands and a consideration of their significance. Ecology 39(3):393-401.

Wynia, R. 2008. Plant Guide for purple prairie clover (*Dalea purpurea*). USDA. Natural Resources Conservation Service. Manhatten Plant Materials Center. Manhatten, KS. http://plants.usda.gov.

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.