Autecology of Silverleaf Scurfpea 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 Silverleaf scurfpea, *Psoralea argophylla*, 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).

Silverleaf scurfpea, *Psoralea argophylla* Pursh, is a member of the legume (bean, pea) family, Fabaceae, syn.: *Pediomelum argophyllum* (Pursh) J. Grimes, *Psoralidium argophyllum* (Pursh) Rybd., and is a native, perennial, cool season, dicot, herb. The first North Dakota record is Stevens 1918. O.A. Stevens proposed the "silverleaf" common name. Annual aerial growth has a single, erect or ascending stem with widely spreading branches above, 20-50 cm (7.9-19.7 in) tall and about 25 cm (10 in) in diameter arising from a subterranian crown (caudex) extending 5-15 cm (2.0-5.9 in) below the soil surface with short branches. Leaves are alternate, palmately compound with stem leaves 4 to 5 foliate and branch leaves 3 foliate, with leaflets obovate to elliptic, 1.5-4 cm (0.6-1.6 in) long. Stems, branches, and leaves are densely covered with long, silky, silvery, close lying, hairs. The root system consists of a main woody taproot developing from the deep crown at about 15 cm (6 in) below the soil surface which has a diameter of about 1.3 cm (0.5 in) and tapers very rapidly, has few to no branches, descends to 1.7 m (5.5 ft) depths in loose soil, and has several short unbranched fine lateral roots along the entire length. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the crown and crown branches. Inflorescence has 3 to 6 flowers in a cluster forming a short raceme on a pedicel arising widely separated upper leaf axils. Flowers are perfect with small blue petals 7-8 mm long appearing during mid June to early September. Fruit is a one seed legume pod. A prominent joint between the aerial stem and subterranian crown forms an abscission during late summer causing the stem to break near the soil surface and the top tumbles before the wind spreading seeds as it travels as a tumbleweed. Aerial parts are not eaten by livestock and are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown and crown branches. This summary information on growth development and regeneration of silverleaf scurfpea was based on works of Weaver and Fitzpatrick 1934, Weaver 1954, 1958; Stevens 1963, Becker 1968, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Silverleaf scurfpea 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 Silverleaf scurfpea 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 Silverleaf scurfpea 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 Silverleaf scurfpea 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

Silverleaf scurfpea resumes annual aerial growth as a single, erect stem with widely spreading branches arising from a subterranian caudex that extends 5-15 cm (2.0-5.9 in) below the soil surface and has short branches. At the point where the aerial stem connects to the subterranian caudex, this prominent joint forms an abscission during late summer causing the stem to break off near the soil surface permitting the top to move before the wind spreading seeds as a tumbleweed. Stems, branches, and leaves are densely covered with long, silvery, hairs. A main woody taproot descends from the deep caudex, tapers rapidly, may branch, and continues to descend to 1.7 m (5.5 ft) deep in loose soil. Several short fine lateral roots develop along the entire length of the taproot. Several small blue flowers form in clusters on short racemes on pedicels arising from leaf axils of the upper and outer branches. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 13 June, the mean first flowers appeared on 3 July, with a very long 11 week flower period from mid June through July and August to the first week of September (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 24.8 cm (9.8 in) with an annual variance in height from 18.0 cm (7.1 in) to 30.0 cm (11.8 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20.0 cm (7.9) to 50.0 cm (19.7 in) tall. The mature stem heights measured during the 1955-1962 study were within or a little 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. Silverleaf scurfpea was found to have low abundance on silty ecological sites. Patterns in the changes of 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 (tables 3, 4, and 5).

On the sandy site of the nongrazed treatment, Silverleaf scurfpea was present during 44.4% and 20.0% of the years that density and basal cover data were collected, with a mean 0.43 stems/m^2 density and a mean 0.014% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 25.0% and 20.0% of the years with a mean 0.15 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 50.0% and 13.3% of the years with a mean 0.51 stems/m^2 density and a mean 0.004% basal cover, respectively. The percent present for density data and stem density increased and percent present for basal cover data and basal cover decreased on the sandy site of the nongrazed treatment over time (tables 3, 4, and 5).

On the sandy site of the ungrazed seasonlong treatment, Silverleaf scurfpea was not present where basal cover data were collected and was present during 5.3% of the years where density data were collected with a mean 0.02 stems/m^2 density. During the early period (1983-1992), Silverleaf scurfpea was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Silverleaf scurfpea was present during 6.7% of the years with a mean 0.03 stems/m^2 density. Silverleaf scurfpea was not present where basal cover data were collected and 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.

On the sandy site of the grazed seasonlong treatment, Silverleaf scurfpea was present during 31.6% and 20.0% of the years that density and basal cover data were collected with a mean 0.10 stems/m^2 density and a mean 0.009% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 50.0% and 40.0% of the years with a mean 0.13 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 26.7% and 6.7% of the years with a mean 0.09 stems/m^2 density and a mean 0.001% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the sandy site of the grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were all greater on the sandy site of the grazed seasonlong treatment than those on the sandy site of the ungrazed seasonlong treatment.

On the sandy site of the ungrazed twice-over treatment, Silverleaf scurfpea was present during 81.0% and 72.4% 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), Silverleaf scurfpea was present during 50.0% and 62.5% of the years with a mean 0.18 stems/m^2 density and a mean 0.018% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 93.3% and 73.3% of the years with a mean 0.49 stems/m^2 density and a mean 0.013% basal cover, respectively. The percent present for density data, percent present for basal cover data and stem density increased, and basal cover decreased 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, Silverleaf scurfpea was present during 85.7% and 55.2% of the years that density and basal cover data were collected with a mean 0.29 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 66.7% and 66.7% of the years with a mean 0.28 stems/m^2 density and a mean 0.018% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 93.3% and 40.0% of the years with a mean 0.29 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present for density data increased, stem density remained the same, and percent present for basal cover data and basal cover decreased on the sandy site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present for density data and basal cover were similar, and percent present for basal cover data and stem density were slightly greater on the sandy site of the ungrazed twice-over treatment than those on the sandy site of the grazed twice-over treatment.

On the shallow site of the nongrazed treatment, Silverleaf scurfpea was present during 47.4% and 26.9% of the years that density and basal cover data were collected with a mean 0.62 stems/m^2 density and a mean 0.014% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 40.0% and 33.3% of the years with a mean 0.20 stems/m^2 density and a mean 0.025% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 50.0% and 20.0% of the years with a mean 0.77 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present for density data and stem density increased and percent present for basal cover data and basal cover decreased on the shallow site of the nongrazed treatment over time (tables 3, 4, and 5).

On the shallow site of the ungrazed seasonlong treatment, Silverleaf scurfpea was present during 45.0% and 3.9% of the years that density and basal cover data were collected with a mean 0.26 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Silverleaf scurfpea was present during 60.0% and 6.7% of the years with a mean 0.35 stems/m^2 density and a mean 0.001% basal cover, respectively. Silverleaf scurfpea was not present during the early period and all observations were made during the later period that indicated moderate to low abundance.

On the shallow site of the grazed seasonlong treatment, Silverleaf scurfpea was present during 60.0% and 30.8% of the years that density and basal cover data were collected with a mean 0.24 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 40.0% and 66.7% of the years with a mean 0.16 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 66.7% and 20.0% of the years with a mean 0.26 stems/m^2 density and a mean 0.004% basal cover, respectively. The percent present for density data and stem density increased, and percent present for basal cover data and basal cover decreased on the shallow site of the grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present and basal cover were greater and stem density was similar 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, Silverleaf scurfpea was present during 90.9% and 72.4% 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), Silverleaf scurfpea was present during 50.0% and 62.5% of the years with a mean 0.66 stems/m^2 density and a mean 0.08% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 86.7% and 53.3% of the years with a mean 0.65 stems/m^2 density and a mean 0.013% basal cover, respectively. The percent present for density data increased, stem density remained the same, and percent present for basal cover 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, Silverleaf scurfpea was present during 86.4% and 70.0% of the years that density and basal cover data were collected with a mean 0.63 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Silverleaf scurfpea was present during 71.4% and 80.0% of the years with a mean 0.44 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Silverleaf scurfpea was present during 93.3% and 60.0% of the years with a mean 0.72 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present for density data and stem density increased, and percent present for basal cover data and basal cover decreased on the shallow 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 shallow site of the ungrazed and grazed twice-over treatments.

On the sandy site, Silverleaf scurfpea was present during 46.9% and 33.5% of the years with a mean 0.25 stems/m^2 density and a mean 0.014% basal cover. On the shallow site, Silverleaf scurfpea was present during 65.9% and 40.8% of the years with a mean 0.48 stems/m^2 density and a mean 0.03% basal cover. The percent present, stem density, and basal cover were greater on the shallow site.

On the sandy site of the nongrazed treatment, Silverleaf scurfpea was present during 44.4% and 20.0% of the years with a mean 0.43 stems/m^2 density and a mean 0.014% basal cover. On the sandy site of the seasonlong treatment, Silverleaf scurfpea was present during 18.4% and 10.0% of the years with a mean 0.06 stems/m^2 density and a mean 0.005% basal cover. On the sandy site of the twice-over treatment, Silverleaf scurfpea was present during 83.3% and 63.8% of the years with a mean 0.35 stems/m^2 density and a mean 0.024% basal cover. The percent present and basal cover were greater on the sandy site of the twice-over treatment and stem density was greater on the sandy site of the nongrazed treatment.

On the shallow site of the nongrazed treatment, Silverleaf scurfpea was present during 47.4% and 26.9% of the years with a mean 0.62 stems/m^2 density and a mean 0.014% basal cover. On the shallow site of the seasonlong treatment, Silverleaf scurfpea was present during 52.5% and 17.3% of the years with a mean 0.25 stems/m^2 density and a mean 0.012% basal cover. On the shallow site of the twice-over treatment, Silverleaf scurfpea was present during 88.6% and 71.2% of the years with a mean 0.64 stems/m^2 density and a mean 0.058% basal cover. The percent present, stem density, and basal cover were greater on the shallow site of the twice-over treatment.

During the drought growing season of 1988; Silverleaf scurfpea was present on the nongrazed treatment 2 times out of a possible 4 for an index of 50.0%; Silverleaf scurfpea was present on the seasonlong treatment 3 times out of a possible 8 for an index of 37.5%; and Silverleaf scurfpea was present on the twice-over treatment 5 times out of a possible 8 for an index of 62.5%. Silverleaf scurfpea has moderate to good drought tolerance on the twice-over and nongrazed treatments and relatively low drought tolerance on the seasonlong treatment.

Discussion

Silverleaf scurfpea, *Psoralea argophylla*, is a native, late succession, perennial, cool season, dicot, forb of the legume family that is commonly present on healthy mixed grass prairie plant communities. Silverleaf scurfpea can grow on sandy and shallow ecological sites. It grows a better on the shallow sites and grows best on shallow sites managed with the twice-over rotation treatment. Annual aerial growth produces a single widely branched stem arising from a perennating caudex that extends 5-15 cm (2.0-5.9 in) into the soil. The main woody taproot can descend to 1.7 m (5.5 ft) deep in loose soil. Several small blue flowers form in clusters on the upper and outer branches. The mean first flower appeared 3 July (1955-1962 study), with a long 11 week flower period from mid June to early September (1969-1971 study). The mean mature stem height of 24.8 cm (9.8 in) was reached during July (1955-1962 study). The stem breaks off in late summer and spreads seeds as a tumbleweed. The abundance of Silverleaf scurfpea was affected by management treatment. The abundance was considerably lower on the seasonlong and nongrazed treatments than that on the twice-over treatment. The level of drought tolerance was also lower on the seasonlong and nongrazed treatments than that on the twice-over treatment.

The perennating deep caudex with branches, the deep taproot and the tumbleweed method to spread seeds help Silverleaf scurfpea to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Psoralea argophylla, Silverleaf scurfpea.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest			13			
Mean				3		
Flower Period						
1969-1971			XX	XX XX	XX XX	X

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

Table 2. Autecology of Psoralea argophylla, Silverleaf scurfpea, 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	18.0	30.0	24.8		37.1	68.3	100.0		

Data from Goetz 1963.

Table 3. Autecology of Psoralea argophylla, Silverleaf scurfpea, 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	7.04	0.00	2.34	2.90	4.19
1988-1992	0.00	0.00	0.31	0.00	0.70
1993-1998	2.52	0.00	2.80	7.58	0.00
1999-2003	0.41	0.46	0.66	4.19	1.97
2004-2009	7.18	0.00	0.07	1.63	2.60
2010-2012	3.35	0.00	0.69	1.40	2.48
Shallow					
1983-1987	4.52	0.00	4.65	6.48	4.57
1988-1992	0.52	0.00	0.61	4.16	1.57
1993-1998	0.00	0.00	0.00	1.03	2.64
1999-2003	0.45	0.65	1.81	2.52	2.28
2004-2009	4.14	2.43	1.50	2.34	2.87
2010-2012	11.15	5.51	2.92	5.72	4.86
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 4. Autecology of Psoralea argophylla, Silverleaf scurfpea, 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	0.26	0.19
1988-1992	0.33	0.00	0.14	0.10	0.08
1993-1998	0.46	0.00	0.14	0.70	0.49
1999-2003	0.04	0.00	0.00	0.25	0.06
2004-2009	0.00	0.00	0.00	0.12	0.05
2010-2012	0.07	0.00	0.05	0.04	0.04
Shallow					
1983-1987	0.00	0.00	0.54	0.23	0.24
1988-1992	0.28	0.00	0.69	1.11	1.07
1993-1998	0.26	0.00	0.23	1.44	0.83
1999-2003	0.00	0.00	0.05	0.08	0.31
2004-2009	0.05	0.02	0.02	0.17	0.10
2010-2012	0.24	0.00	0.00	0.00	0.14
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 5. Autecology of Psoralea argophylla, Silverleaf scurfpea, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.06	0.00	0.04	0.04	0.05
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.04	0.00	0.03	0.14	0.00
1999-2003	0.01	0.01	0.01	0.07	0.03
2004-2009	0.08	0.00	0.00	0.03	0.03
2010-2012	0.05	0.00	0.01	0.02	0.03
Shallow					
1983-1987	0.02	0.00	0.01	0.12	0.08
1988-1992	0.01	0.00	0.01	0.03	0.02
1993-1998	0.00	0.00	0.00	0.01	0.06
1999-2003	0.01	0.01	0.03	0.06	0.05
2004-2009	0.03	0.04	0.02	0.06	0.08
2010-2012	0.28	0.08	0.04	0.12	0.09
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

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