Autecology of Wavyleaf Thistle on the Northern Mixed Grass Prairie

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The autecology of Wavyleaf thistle, *Cirsium undulatum*, 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).

Wavyleaf thistle, *Cirsium undulatum* (Nutt.) Spreng., is a member of the aster (sunflower) family, Asteraceae, and is a native, short lived perennial, warm season, dicot, herb. The first North Dakota record is Waldron 1904. First year aerial growth consists of a rosette of large leaves without waves along with the early development of the crown and taproot. Annual aerial growth has a stout single stem nearly round in cross section, 40-80 cm (15.7-31.5 in) tall, simple below and few branches above arising from a perennating crown (caudex). Basal leaves are elliptic to oblanceolate, 10-30 cm (3.9-11.8 in) long, 2-7 cm (0.8-2.8 in) wide, deeply pinnately divided with undulate (wary) margins, and each lobe is tipped with a yellow spine 5 mm long. Stem leaves are alternate, ovate to lanceolate, 8-20 cm (3.1-7.9 in) long, deeply pinnately divided with undulate margins and a spine at the tip of each lobe, sessile and clasping. Underside of leaves is light colored. Stems and leaves are densely covered with hairs. The root system has a stout, thick, deep, subterranian taproot and several horizontal runner roots (that are not rhizomes) produce tufts of roots at nodes along with adventitious root buds from which patches can develop. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown, offset shoots can be produced at the crown branches, and shoots can develop at the adventitious root buds. Inflorescence are large, urn shaped, solitary heads 4-7 cm (1.6-2.8 in) wide terminal on peduncles arising from leaf axils. Flowers are purple or pinkish purple disk florets appearing during late June to early August. Fruit is an achene with pappus of white bristles. Aerial stems and leaves are not eaten by livestock, however, the flower heads are sampled by some individual animals. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown branches and from the root buds. This summary information on growth development and regeneration of wavyleaf thistle was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Wavyleaf thistle 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 Wavyleaf thistle 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 Wavyleaf thistle 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 Wavyleaf thistle 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

Wavyleaf thistle resumes as a single stout, transversely round stem, simple below and few branches above arising from a perennating caudex. A thick deep taproot descends from the caudex producing horizontal runner roots and adventitious root buds. Tufts of roots form at root nodes. Vegetative sprouts arise from crown branches and root buds. First year aerial growth consists of a rosette of large leaves 10-30 cm (4-12 in) long without waves. Stem leaves are 8-20 cm (3.1-7.9 in) long, deeply pinnately divided with undulating margins (wavy hence the name) with a yellow spine 5 mm long tipped on each lobe. Stems and leaves are densely covered with hairs. The inflorescence are large, urn shaped, solitary composite head with purple to pinkish purple disk florets. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 28 June, the mean first flowers occurred on 7 July, and the six week flower period extended from the last week of June through the first week of August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 43.6 cm (17.2 in) with an annual variance in height from 30.0 cm (11.8 in) to 59.0 cm (23.2 in) was reached during

August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 40 cm (15.7 in) to 80.0 cm (31.5 in) tall. The stem heights measured during the 1955-1961 study were within the short end 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. Wavyleaf thistle was found to have low abundance on the shallow 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 sandy 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, Wavyleaf thistle was present during 61.1% and 16.0% of the years that density and basal cover data were collected with a mean 0.14 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wavyleaf thistle was present during 25.0% and 20.0% of the years with a mean 0.05 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Wavyleaf thistle was present during 71.4% and 20.0% of the years with a mean 0.17 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present for the density data and stem density increased, percent present for the basal cover data remained the same, 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, Wavyleaf thistle was present during 5.3% and 8.0% of the years that density and basal cover data were collected with a mean 0.005 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wavyleaf thistle was not present on the sandy site of the grazed seasonlong treatment. During the later period (1998-2012), Wavyleaf thistle was present during 6.7% and 13.3% of the years with a mean 0.007 stems/m^2 density and a mean 0.003% basal cover, respectively. Wavyleaf thistle was not present during the early period and all observations were made during the later period that indicated low abundance.

On the sandy site of the grazed seasonlong treatment, Wavyleaf thistle was present during 73.7% and 36.0% of the years that density and basal cover data were collected with a mean 0.22 stems/m^2 density and a mean 0.012% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wavyleaf thistle was present during 75.0% and 40.0% of the years with a mean 0.28 stems/m^2 density and a mean 0.028% basal cover, respectively. During the later period (1998-2012), Wavyleaf thistle was present during 73.3% and 33.3% of the years with a mean 0.20 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present for density data, percent present for basal cover data, 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, Wavyleaf thistle was present during 71.4% and 62.1% of the years that density and basal cover data were collected with a mean 0.18 stems/m^2 density and a mean 0.017% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wavyleaf thistle was present during 33.3% and 50.02% of the years with a mean 0.07 stems/m^2 density and a mean 0.021% basal cover, respectively. During the later period (1998-2012), Wavyleaf thistle was present during 86.7% and 73.3% of the years with a mean 0.22 stems/m^2 density and a mean 0.016% basal cover, respectively. The percent present 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, Wavyleaf thistle was present during 76.2% and 55.2% of the years that density and basal cover data were collected with a mean 0.16 stems/m^2 density and a mean 0.016% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wavyleaf thistle was present during 50.0% and 66.7% of the years with a mean 0.20 stems/m^2 density and a mean 0.034% basal cover, respectively. During the later period (1998-2012), Wavyleaf thistle was present during 86.7% and 53.3% of the years with a mean 0.15 stems/m^2 density and a mean 0.009% basal cover, respectively. The percent present for the density data increased and percent present for the basal cover data, stem density, and basal cove decreased on the sandy 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 sandy sites of the ungrazed and grazed twice-over treatment.

On the sandy sites, Wavyleaf thistle was present during 57.5% and 35.5% of the years with a mean 0.14 stems/m^2 density and a mean 0.01% basal cover indicates a relatively low abundance.

Wavyleaf thistle on the sandy site of the nongrazed treatment was present during 61.1% and 16.0% of the years with a mean 0.14 stems/m^2 density and a mean 0.01% basal cover. Wavyleaf thistle on the sandy site of the seasonlong treatment was present during 39.5% and 22.0% of the years with a mean 0.10 stems/m^2 density and a mean 0.01% basal cover. Wavyleaf thistle on the sandy site of the twice-over treatment was present during 73.8% and 58.6% of the years with a mean 0.17 stems/m^2 density and a mean 0.02% basal cover. The percent present, stem density, and basal cover were greater on the sandy site of the twice-over treatment than those on the sandy sites of the nongrazed and seasonlong treatments.

Discussion

Wavyleaf thistle, *Cirsium undulatum*, is a native, late succession, perennial, warm season dicot, forb of the aster family that is commonly present on healthy mixed grass prairie plant communities. Wavyleaf thistle grows better on sandy ecological sites and grows best on sandy sites managed by the twice-over rotation treatment. Annual aerial growth resumes as a single, stout, erect stem arising from a persistent caudex. A deep, stout, thick subterranean taproot descends below the caudex. Several runner roots (not rhizomes) grow horizontally from the taproot producing nodes and root buds. Vegetative sprouts develop from caudex branches and root buds with tufts of roots developing at the root nodes. First year aerial growth consists of a rosette of large leaves without waves 10-30 cm (4-12 in) long. Stems and leaves are densely covered with hairs. Large urn shaped composite head flowers develop terminal on the stem. The mean first flowers occurred on 7 July (1955-1962 study), with a six week flower period extending from late June through early August (1969-1971 study). A mean mature stem height of 43.6 cm (17.2 in) was reached during August (1955-1962 study).

The perennating caudex, the deep stout taproot, and the adventitious horizontal runner roots with productive nodes and root buds help Wavyleaf thistle to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Cirsium undulatum, Wavyleaf prairie thistle.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest			28			
Mean				7		
Flower Period						
1969-1971			X	XX XX	X	

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

Table 2. Autecology of Cirsium undulatum, Wavyleaf prairie thistle, 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	30.0	59.0	43.6	25.0	27.9	74.1	96.7	100.0	

Data from Goetz 1963.

Table 3. Autecology of Cirsium undulatum, Wavy leaf thistle or Prairie thistle, 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	0.15	0.42
1988-1992	1.15	0.00	3.59	0.63	2.31
1993-1998	0.00	0.00	1.74	0.42	0.91
1999-2003	1.01	0.00	1.13	1.14	0.43
2004-2009	1.13	0.10	0.87	1.08	1.32
2010-2012	0.80	0.00	0.00	2.21	0.95
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 4. Autecology of Cirsium undulatum, Wavy leaf thistle or Prairie thistle, 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	0.57	0.12	0.30
1988-1992	0.10	0.00	0.11	0.19	0.14
1993-1998	0.00	0.00	0.13	0.12	0.03
1999-2003	0.20	0.00	0.05	0.19	0.08
2004-2009	0.00	0.02	0.05	0.24	0.04
2010-2012	0.00	0.05	0	0.08	0.10
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Silty					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					

Table 5. Autecology of Cirsium undulatum, Wavy leaf thistle or Prairie thistle, 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	0.00	0.01
1988-1992	0.01	0.00	0.04	0.01	0.03
1993-1998	0.00	0.00	0.03	0.01	0.01
1999-2003	0.02	0.00	0.03	0.02	0.01
2004-2009	0.02	0.00	0.02	0.02	0.02
2010-2012	0.01	0.00	0.00	0.04	0.01
Shallow					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
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.

Johnson, J.R., and G.E. Larson. 2007. Grassland plants of South Dakota and the Northern Great Plains. South Dakota University. B 566 (rev.). Brookings, SD.

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.

Stubbendieck, J., M.J. Coffin, and L.M. Landholt. 2003. Weeds of the Great Plains. Nebraska Department of Agriculture. Lincoln, NE.

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.