Autecology of Stiff Sunflower on the Northern Mixed Grass Prairie

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The autecology of Stiff sunflower, *Helianthus rigidus*, 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).

Stiff sunflower, *Helianthus rigidus* (Cass.) Desf., is a member of the aster (sunflower) family, Asteraceae, syn.: *Helianthus scaberrimus* Ell., *Helianthus pauciflorus* Nutt., and is a native perennial, warm season, dicot, herb. The first North Dakota record is Stevens 1961. Early aerial growth consists of a basal rosette of stiff long leaves. Annual aerial growth has a single, erect, stiff, rough, stem tinged reddish to purple with few branches above 80-150 cm (31.5-59.1 in) tall arising from an enlarged perennating crown (caudex). Lower stem (cauline) leaves are opposite, elliptic, linear, to lanceolate, or ovate 5-15 cm (2.0-5.9 in) long, thick leathery, rough, gray-green to light green with three prominent ribs. The root system arises from the crown with several large tough woody roots that have a radial spread of 46 cm (1.5 ft) horizontally before turning downward to a depth of 1.5 m (5 ft). Numerous short, fine, fibrous roots branch from the large roots with a dense concentration of fine highly branched roots in the top 30.5 cm (12 in) of soil providing the capacity of great absorption. Several stout rhizomes extend outward from the crown horizontally to 46 cm (1.5 ft) at a depth between 7.6 to 10.2 cm (3-4 in) and 15.2 to 20.3 cm (6-8 in) from which patches or open colonies are formed. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown and numerous sprouts can arise from the rhizome system. Inflorescence are one to several long bare peduncles each with a single terminal head 4-8 cm (1.6-3.1 in) wide. Flowers are perfect, ray florets are yellow that appear during late July to mid August. Fruit is an achene 5-6 mm long. Aerial parts are sometimes eaten by livestock and is top killed by fire. Sprouts can be activated to develop from the crown and rhizomes. This summary information on growth development and regeneration of stiff sunflower was based on works of Weaver and Fitzpatrick 1934, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Knudson and Tober 2002, and Johnson and Larson 2007.

Procedures

The 1955-1962 Study

Stiff sunflower 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 Stiff sunflower 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 Stiff sunflower 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 Stiff sunflower 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

Stiff sunflower resumed early aerial growth with a basal rosette of stiff long leaves and later produced a single, erect, stiff, rough stem tinged reddish to purple with few branches above arising from a large perennating caudex. An extensive root system arises from the bottom of the caudex with several large tough main woody roots that spread radially out for 46 cm (1.5 ft) horizontally then turning downward to a 1.5 m (5 ft) depth. Numerous branching fibrous roots arise from the large main roots forming a dense concentration of fine highly branched roots in the top 30.5 cm (12 in) of soil with the capacity of great absorption. A stout extensive rhizome system extends outward from the caudex 46 cm (1.5 ft) horizontally and can form patches or open colonies. Several terminal composite heads with yellow ray florets develop on long bare peduncles arising from the upper portions of the stem. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared on 25 July, the mean first flowers occurred on 3 August, and the short 3 week flower period extended from late July to mid August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 28.6 cm (11.3 in) with an annual variance in height from 19.0 cm (7.5 in) to 35.0 cm (13.8 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 80 cm

(31.5 in) to 150 cm (59.1 in) tall. The mature stem heights measured during the 1955-1962 study were much shorter than the normal height of mature stems for the Northern Plains. The shorter heights of Stiff sunflower on the 1955-1962 study was not caused directly by grazing effects but was caused by low quantities of available mineral nitrogen below the threshold levels of 100 lbs/ac in the soil as a result of detrimental effects from traditional management practices.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Stiff sunflower has been found to have low abundance on the shallow and 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 ecological site of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments.

On the sandy site of the nongrazed treatment, Stiff sunflower was present during 55.6% and 52.0% of the years that density and basal cover data were collected with a mean 15.61 stems/m^2 density and a mean 0.42% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Stiff sunflower was present during 75.0% and 60.0% of the years with a mean 3.40 stems/m^2 density and a mean 0.43% basal cover, respectively. During the later period (1998-2012), Stiff sunflower was present during 50.0% and 53.3% of the years with a mean 19.1 stems/m^2 density and a mean 0.51% basal cover, respectively. The percent present for density data and percent present for basal cover data decreased and stem density and basal cover increased on the sandy site of the nongrazed treatment.

On the sandy site of the ungrazed seasonlong treatment, Stiff sunflower was not present where basal cover data were collected and was present during 5.3% of the years that density data were collected with a mean 0.12 stems/m^2 density during the total 30 year period, respectively. During the early period (1983-1992), Stiff sunflower was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Stiff sunflower was present during 50.0% and 53.3% of the years with a mean 19.10 stems/m^2 density and a mean 0.51% basal cover, respectively. Stiff sunflower was not present where basal cover were collected and was not present during the early period with density data and all observations were made during the later period that indicated low abundance.

On the sandy site of the grazed seasonlong treatment, Stiff sunflower was present during 47.4% and 40.0% of the years that density and basal cover data were collected with a mean 0.86 stems/m^2 density and a mean 0.033% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Stiff sunflower was present during 50.0% and 20.0% of the years with a mean 0.25 stems/m^2 density and a mean 0.034% basal cover, respectively. During the later period (1998-2012), Stiff sunflower was present during 46.7% and 60.0% of the years with a mean 1.03 stems/m^2 density and a mean 0.044% basal cover, respectively. The percent present for density data decreased and percent present for basal cover data, stem density, and basal cover increased 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 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, Stiff sunflower was present during 90.5% and 79.3% of the years that density and basal cover data were collected with a mean 16.39 stems/m^2 density and a mean 0.35% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Stiff sunflower was present during 66.7% and 62.5% of the years with a mean 0.82 stems/m^2 density and a mean 0.08% basal cover, respectively. During the later period (1998-2012), Stiff sunflower was present during 100.0% and 100.0% of the years with a mean 22.63 stems/m^2 density and a mean 0.57% basal cover, respectively. The percent present, stem density, and basal cover all increased greatly 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, Stiff sunflower was present during 95.2% and 62.1% of the years that density and basal cover data were collected with a mean 2.07 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Stiff sunflower was present during 83.3% and 44.4% of the years with a mean 0.85 stems/m^2 density and a mean 0.06% basal cover, respectively. During the later period (1998-2012), Stiff sunflower was present during 100.0% and 93.3% of the years with a mean 2.55 stems/m^2 density and a mean 0.07% 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 all much 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 sandy site, Stiff sunflower was present during 58.8% and 46.7% of the years with a mean 7.01 stems/m^2 density and a mean 0.17% basal cover that indicated good abundance.

Stiff sunflower was present on the sandy site of the nongrazed treatment during 55.6% and 52.0% of the years with a mean 15.61 stems/m^2 density and a mean 0.42% basal cover. Stiff sunflower was present on the sandy site of the seasonlong treatment during 26.3% and 20.0% of the years with a mean 0.49 stems/m^2 density and a mean 0.017% basal cover. Stiff sunflower was present on the sandy site of the twice-over treatment during 92.9% and 70.7% of the years with a mean 9.23 stems/m^2 density and a mean 0.20% basal cover. The percent present for density data and percent present for basal cover data were greater on the sandy site of the twice-over treatment and the stem density and basal cover were greater on the nongrazed treatment.

During the drought growing season of 1988; Stiff sunflower was present on the nongrazed treatment 2 times out of a possible 2 for an index of 100.0%; Stiff sunflower was present on the seasonlong treatment 1 time out of a possible 4 for an index of 25.0%; and Stiff sunflower was present on the twice-over treatment 2 times out of a possible 4 for an index of 50.0%. Stiff sunflower appears to have fairly good drought tolerance on the nongrazed and twice-over treatments.

Discussion

Stiff sunflower, *Helianthus rigidus*, 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. Stiff sunflower grows best on sandy ecological sites and reaches high densities on nongrazed and ungrazed treatments. Annual aerial growth resumes early with a basal rosette of stiff long leaves followed by a stiff, rough, red stem arising from a perennating caudex. Several large main woody roots spread radially from the caudex. Numerous branching roots arise from the large main roots forming an extensive concentration of a highly absorbent root system. Several short rhizomes extend horizontally from the caudex that can form patches or open colonies. Single terminal composite heads with yellow ray florets develop on long bare peduncles. The mean first flower date is 3 August (1955-1962 study) with a 3 week flower period from late July to mid August (1969-1971 study). Mean mature stem height of 28.6 cm (11.3 in) was reached during August (1955-1962 study). The greatest percent present for density data and percent present for basal cover data were on the sandy site of the twice-over treatment. The greatest stem density and basal cover were on the sandy site of the nongrazed and ungrazed twice-over treatments. Stiff sunflower had fairly good drought tolerance on the sandy sites of the nongrazed and twice-over treatments.

The perennating caudex, extensive fine branching absorbent root system, and stout rhizome system help Stiff sunflower to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Helianthus rigidus, Stiff sunflower.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest				25		
Mean					3	
Flower Period						
1969-1971				X	XX	

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

Table 2. Autecology of Helianthus rigidus, Stiff sunflower, 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	35.0	28.6		18.7	31.2		100.0	

Data from Goetz 1963.

Table 3. Autecology of Helianthus rigidus, Stiff sunflower, 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	36.86	0.00	4.39	6.03	5.26
1988-1992	33.33	0.00	0.75	1.49	2.85
1993-1998	59.14	0.00	0.00	37.27	3.89
1999-2003	93.86	0.00	1.13	51.19	8.93
2004-2009	22.54	0.00	4.43	58.00	14.64
2010-2012	0.00	2.94	1.19	51.27	13.16
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 Helianthus rigidus, Stiff sunflower, 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	3.01	0.00	1.43	0.86	0.87
1988-1992	4.02	0.00	0.00	0.55	0.00
1993-1998	1.81	0.00	0.00	2.20	0.04
1999-2003	11.93	0.00	0.38	7.81	0.70
2004-2009	2.00	0.00	0.56	8.36	0.79
2010-2012	0.00	0.00	0.14	4.53	0.51
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 Helianthus rigidus, Stiff sunflower, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.60	0.00	0.07	0.14	0.12
1988-1992	0.25	0.00	0.01	0.02	0.06
1993-1998	2.38	0.00	0.00	1.50	0.09
1999-2003	5.42	0.00	0.05	2.11	0.17
2004-2009	0.45	0.00	0.20	2.23	0.29
2010-2012	0.00	0.08	0.04	2.84	0.39
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					

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