Autecology of White Beardtongue on the Northern Mixed Grass Prairie

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The autecology of White Beardtongue, *Penstemon albidus*, 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).

White Beardtongue, *Penstemon albidus* Nutt., is a member of the figwort family, Scrophulariaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bolley and Lee 1891. Annual aerial growth has 1 to 5 erect or ascending stocky somewhat sticky stems 20-40 cm (7.9-15.7 in) tall arising from a persistent, short, branched caudex. Stem leaves are opposite, thick, lanceolate, 5-8 cm (2.0-3.1 in) long, reduced upward. Stems and leaves can be glabrous but usually covered with fine, short hairs. This root system is a taproot with fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the caudex and by sprouts from the branches of the caudex. Inflorescence has clusters of a few flowers, compounded by numerous clusters along the top portion of the stem. Flowers are perfect with white corollas appearing during late May to early July. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown and from the crown branches. This summary information on growth development and regeneration of white beardtongue was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

White beardtongue 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 White beardtongue 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 White beardtongue 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 White beardtongue 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

White beardtongue resumes annual aerial growth with a few erect, stocky, sticky stems arising from short, branched, persistent caudex. A taproot with fibrous lateral roots descends downward from beneath the caudex. Perfect flowers with white corollas develop into numerous clusters. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 19 May, the mean first flowers occurred on 8 June, a 6 week flower period extends from late May to early July (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 18.1 cm (7.1 in) with an annual variance in height from 13.0 cm (5.1 in) to 25.0 cm (9.8 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20 cm (7.9 in) to 40 cm (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. The shorter stem heights were 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. Patterns in the changes of individual plant species abundance was followed for 30 growing seasons during the 1983-2012 study on the sandy, shallow, and silty 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, White beardtongue was not present during the total 30 year period.

On the sandy site of the ungrazed seasonlong treatment, White beardtongue was not present during the total 30 year period.

On the sandy site of the grazed seasonlong treatment, White beardtongue was not present during where density data was collected and was present 4.0% of the years that basal cover data were collected with a mean 0.002% basal cover during the total 30 year period. During the early period (1983-1992), White beardtongue was not present on the sandy site of the grazed seasonlong treatment. During the later period (1998-2012), White beardtongue was present during 6.7% of the years with a mean 0.003% basal cover. White beardtongue was not present where density 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. The abundance of White beardtongue was slightly more on the sandy site of the grazed seasonlong treatment than that on the sandy site of the ungrazed seasonlong treatment. The abundance of White beardtongue on the sandy site of the seasonlong treatment was very low.

On the sandy site of the ungrazed twice-over treatment, White beardtongue was present during 4.8% and 3.5% of the years that density and basal cover data were collected with a mean 0.14 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), White beardtongue was present during 16.7% and 12.5% of the years with a mean 0.05 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), White beardtongue was not present on the sandy site of the ungrazed twice-over treatment. White beardtongue was not present during the later period and all observations were made during the early period that indicated low abundance.

On the sandy site of the grazed twice-over treatment, White beardtongue was not present where basal cover data were collected and was present during 9.5% of the years that density data were collected with a mean 0.019 stems/m^2 density during the total 30 year period. During the early period (1983-1992), White beardtongue was present during 16.7% of the years with a mean 0.05 stems/m^2 density. During the later period (1998-2012), White beardtongue was present during 6.7% of the years with a mean 0.007 stems/m^2 density. The percent present for density data and stem density decreased on the sandy site of the grazed twice-over treatment over time (table 3). The percent present for density data and stem density were slightly greater on the sandy site of the grazed twice-over treatment and percent present for basal cover data and basal cover were slightly greater on the sandy site of the ungrazed twice-over treatment. The abundance of White beardtongue on the sandy site of the twice-over treatment was very low.

On the shallow site of the nongrazed treatment, White beardtongue was not present during the total 30 year period.

On the shallow site of the ungrazed seasonlong treatment, White beardtongue was not present during the total 30 year period.

On the shallow site of the grazed seasonlong treatment, White beardtongue was present during 15.0% and 7.7% of the years that density and basal cover data were collected with a mean 0.35 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), White beardtongue was not present on the shallow site of the grazed seasonlong treatment. During the later period (1998-2012), White beardtongue was present during 20.0% and 13.3% of the years with a mean 0.047 stems/m^2 density and a mean 0.003% basal cover, respectively. White beardtongue was not present during the early period and all observations were made during the later period that indicated low abundance. The abundance of White beardtongue was slightly more on the shallow site of the grazed seasonlong treatment than that on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, White beardtongue was present during 9.1% and 6.9% of the years that density and basal cover data were collected with a mean 0.018 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), White beardtongue was present during 28.6% and 11.1% of the years with a mean 0.067 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), White beardtongue was not present where density data were collected and was present during 6.7% of the years with a mean 0.001% basal cover. White beardtongue was not present where density data were collected during the later period and all density observations were made during the early period indicated low abundance. The percent

present for basal cover data and basal cover decreased slightly on the shallow site of the ungrazed twice-over treatment over time (table 4).

On the shallow site of the grazed twice-over treatment, White beardtongue was not present where basal cover data were collected and was present during 22.7% of the years that density were collected with a mean 0.086 stems/m^2 density during the total 30 year period. During the early period (1983-1992), White beardtongue was present during 28.6% of the years with a mean 0.067 stems/m^2 density. During the later period (1998-2012), White beardtongue was present during 20.0% of the years with a mean 0.10 stems/m^2 density. White beardtongue was not present where basal cover data were collected. The percent present for density data decreased slightly and stem density increased slightly on the shallow site of the ungrazed twice-over treatment over time (tables 3 and 5). The percent present for density data and stem density was slightly greater on the shallow site of the grazed twice-over treatment and the percent present for basal cover data and basal cover was slightly greater on the shallow site of the ungrazed twice-over treatment.

On the silty site of the nongrazed treatment, White beardtongue 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 0.011 stems/m^2 density during the total 30 year period. During the early period (1983-1992), White beardtongue was not present on the silty site of the nongrazed treatment. During the later period (1998-2012), White beardtongue was present during 7.1% of the years with a mean 0.014 stems/m^2 density. White beardtongue was not present where basal cover data were collected. White beardtongue was not present where density data were collected during the early period and all observations were made during the later period that indicated very low abundance.

On the silty site of the ungrazed seasonlong treatment, White beardtongue was present during 5.0% and 3.9% of the years that density and basal cover were collected with a mean 0.005 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), White beardtongue was not present where basal cover data were collected and was present during 20.0% of the years with a mean 0.02 stems/m^2 density. During the later period (1998-2012), White beardtongue was not present where density data were collected and was present during 6.7% of the years with a mean 0.001% basal cover. White beardtongue was not present during the early period where basal cover data were collected and during the later period where density data were collected, and all basal cover observations were made during the later period and all density observations were made during the early period that indicated low abundance.

On the silty site of the grazed seasonlong treatment, White beardtongue was not present during the total 30 year period. White beardtongue abundance was slightly more on the silty site of the ungrazed seasonlong treatment than that on the silty site of the grazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, White beardtongue was present during 4.6% and 6.9% of the years that density and basal over data were collected with a mean 0.009 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, resepectively. During the early period (1983-1992), White beardtongue was present during 14.3% and 11.1% of the years with a mean 0.029 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), White beardtongue was not present where density data were collected and was present during 6.7% of the years with a mean 0.001% basal cover. White beardtongue was not present where density data were collected during the later period and all density observations were made during the early period that indicated low abundance. The percent present for basal cover data and basal cover decreased slightly on the silty site of the ungrazed twice-over treatment over time (table 4).

On the silty site of the grazed twice-over treatment, White beardtongue was present during 4.6% and 6.7% of the years that density and basal cover data were collected with a mean 0.032 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), White beardtongue was present during 14.3% and 10.0% of the years with a mean 0.10 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), White beardtongue was not present where density data were collected and was present during 6.7% of the years with a mean 0.001% basal cover. White beardtongue was not present where density data were collected during the later period and all density observations were made during the early period that indicated low abundance. The percent present for basal cover data and basal cover decreased slightly on the silty site of the grazed twice-over treatment over time (table 4). The percent present for density data and percent present for basal

cover data were similar on the silty site of the ungrazed and grazed twice-over treatment and stem density and basal cover were slightly greater on the silty site of the grazed twice-over treatment than those on the silty site of the ungrazed twice-over treatment.

On the sandy site, White beardtongue was present during 2.9% and 1.5% of the years with a mean 0.007 stems/m^2 density and a mean 0.001% basal cover. On the shallow site, White beardtongue was present during 9.4% and 2.9% of the years with a mean 0.028 stems/m^2 density and a mean 0.001% basal cover. On the silty site, White beardtongue was present during 3.9% and 3.5% of the years with a mean 0.011 stems/m^2 density and a mean 0.002% basal cover. The percent present for density data and stem density were greater on the shallow site and percent present for basal cover data and basal cover were greater on the silty site.

White beardtongue on the sandy site of the nongrazed treatment was not present. White beardtongue on the sandy site of the seasonlong treatment was not present with density data and was present during 2.0% of the years with a mean 0.001% basal cover. White beardtongue on the sandy site of the twice-over treatment was present during 7.1% and 1.7% of the years with a mean 0.017 stems/m^2 density and a mean 0.001% basal cover. The percent present for density data and stem density were greater on the sandy site of the twice-over treatment and percent present for basal cover data and basal cover were greater on the sandy site of the seasonlong treatment.

White beardtongue on the shallow site of the nongrazed treatment was not present. White beardtongue on the shallow site of the seasonlong treatment was present during 7.5% and 3.8% of the years with a mean 0.018 stems/m^2 density and a mean 0.001% basal cover. White beardtongue on the shallow site of the twice-over treatment was present during 15.9% and 3.5% of the years with a mean 0.052 stems/m^2 density and a mean 0.001% basal cover. The percent present for density data and stem density were greater on the shallow site of the twice-over treatment and percent present for basal cover data and basal cover were greater on the shallow site of the seasonlong treatment.

White beardtongue on the silty site of the nongrazed treatment was present during 5.3% and 0.0% of the years with a mean 0.011 stems/m^2 density and a mean 0.0% basal cover. White beardtongue on the silty site of the seasonlong treatment was present during 2.5% and 1.9% of the years with a mean 0.003 stems/m^2 density and a mean 0.001% basal cover. White beardtongue on the silty site of the twice-over treatment was present during 4.6% and 6.8% of the years with a mean 0.021 stems/m^2 density and a mean 0.004% basal cover. The percent present for density data was greater on the silty site of the nongrazed treatment and the percent present for basal cover data, stem density, and basal cover were greater on the silty site of the twice-over treatment.

Discussion

White beardtongue, *Penstemon albidus*, is a native, late succession, perennial, dicot, forb of the figwort family that is commonly present on healthy mixed grass prairie plant communities. White beardtongue can grow on sandy, shallow, and silty ecological sites. Annual aerial growth resumes with a few erect, stocky, sticky stems arising from a short branching perennating caudex. A taproot descends from the caudex and has numerous fibrous lateral roots. Numerous white flowers form into clusters. The mean first flowers occurred on 8 June (1955-1962 study), a 6 week flower period extends from late May through early July (1969-1971 study). The mean mature stem height of 18.1 cm (7.1 in) was reached during July (1955-1962 study).

During the total 30 year period, White beardtongue was present 28 times. White beardtongue was present on the sandy site 5 times (17.9%), present on the shallow site 14 times (50.0%), and present on the silty site 9 times (32.1%). White beardtongue was present on the nongrazed treatment 1 time (3.6%), and present on the seasonlong treatment 8 times (28.6%), and present on the twice-over treatment 19 times (67.9%). White beardtongue had greater abundance on the shallow site and on the twice-over treatment.

The perennating caudex, and descending taproot helped White beardtongue to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Penstemon albidus, White beardtongue.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		19				
Mean			8			
Flower Period						
1969-1971		X	XX	XX X		

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

Table 2. Autecology of Penstemon albidus, White beardtongue, 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	13.0	25.0	18.1		70.6	89.4	100.0		

Data from Goetz 1963.

Table 3. Autecology of Penstemon albidus, White beardtongue, 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	0.62	0.90
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.59
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.00	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	0.69	0.50
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.33	0.00	0.64
2004-2009	0.00	0.00	0.28	0.00	0.19
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.53	0.00	0.36	0.82
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.13	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 4. Autecology of Penstemon albidus, White beardtongue, 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	0.03	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.09	0.00	0.00
2004-2009	0.00	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	0.03	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.02	0.00	0.00
2004-2009	0.00	0.00	0.02	0.01	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.00	0.00	0.00	0.14
1988-1992	0.00	0.00	0.00	0.04	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.02	0.00	0.02	0.03
2004-2009	0.00	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 5. Autecology of Penstemon albidus, White beardtongue, 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	0.01	0.01
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.01
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.00	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	0.01	0.01
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.01	0.00	0.02
2004-2009	0.00	0.00	0.01	0.00	0.01
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.00	0.00	0.01	0.02
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.00	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00

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