Autecology of Wooly Plantain on the Northern Mixed Grass Prairie

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The autecology of Wooly Plantain, *Plantago patagonica,* 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).

Wooly Plantain, *Plantago patagonica* Jacq., is a member of the plantain family, Plantaginaceae, syn.: *Plantago purshii* Roemer & Schultes, and is a native, winter annual or annual, rarely biennial, dicot, herb. The first North Dakota record is Bolley 1891. First year aerial growth during late summer or fall consists of a basal rosette of narrowly oblanceolate to nearly obovate leaves 0.5-3 cm (0.2-1.2 in) long and the early development of an inconspicious crown of 2 to 4 short congested branches and the taproot. Second year aerial growth has set of basal leaves, linear to oblanceolate 2-15 cm (0.8-5.9 in) long, 0.5-7 mm wide and no stems (acaulescent) develop. The entire plant is densely covered with white silky hairs giving a gray wooly appearance. The root system has a short taproot with fine fibrous lateral roots. Regeneration is by sexual reproduction. Inflorescence is a dense, cylindrical spike 1-15 cm (0.4-5.9 in) long on a leafless scape 5-32 cm (2-12.6 in) tall with 1 to 20 per plant arising from the crown. Flowers are perfect with 4 white petals 1-2 mm long appearing during early June to early August. Fruit is a tiny dehiscent (breaking at the middle) capsule with 2 reddish tan seeds. Aerial parts are not eaten by livestock and are top killed by fire. Growth post fire is from seed. This summary information on growth development and regeneration of wooly plantain was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Stubbendieck et al. 2011.

Procedures

The 1955-1962 Study

Wooly plantain 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 Wooly plantain 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 1984-1985 Study

Wooly plantain plant growth in height was determined by measuring stems from ground level to top of stem or leaf or to the tip of the inflorescence of 38 ungrazed specimens randomly selected on three replications of grazed sandy, shallow, silty, and clayey ecological sites biweekly during June, July, and August of the growing seasons of 1984 and 1985. Phenological growth stage of each specimen was recorded as vegetative, budding, anthesis, seed developing, seed shedding, or mature. Percentage of stem dryness of each specimen was recorded as 0, 0-2, 2-25, 25-50, 50-75, 75-98, or 100 percent dry. Mean stem weight was determined by clipping at ground level 35 specimens at typical phenological growth stages at biweekly sample dates on separate grazed areas of the sandy, shallow, silty, and clayey ecological sites. Clipped stems at each sample site were placed in separate labeled paper bags of known weight, oven dried at 62° C (144° F), and weighed in grams.

The 1983-2012 Study

A long-term study on change in abundance of Wooly plantain 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 Wooly plantain 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

Wooly plantain grew from seed during late summer or early fall and/or early spring when above average precipitation occurred. Early aerial growth consists of a rosette of small basal leaves arising from a crown with a short taproot. Later aerial growth produces a rosette of larger basal leaves. No stems develop. The inflorescence is a dense, cylindrical spike on a leafless scape. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 18 June, the mean first flowers occurred on 11 July, and the four week flower period observed during the 1969-1971 study, extended from early June to late June (table 1) (Goetz 1963, Zaczkowski

1972). A mean height of the flower stalks of 14.0 cm (5.5 in) with an annual variance in height from 9.0 cm (3.5 in) to 22.0 cm (8.7 in) was reached during July. The reported normal flower stalk height in the Northern Plains ranged from 5 cm to 32 cm (2.0-12.6 in) tall. The mean flower stalk heights collected during the 1955-1962 study were within the normal height range for the Northern Plains.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 3,537 Wooly plantain stems were sampled during this study with, 688 stems (19.5%) from the sandy sites, 764 stems (21.6%) from the shallow sites, 1188 stems (33.6%) from the silty sites, and 897 stems (25.4%) from the clayey sites. Wooly plantain can grow on sandy, shallow, silty, and clayey ecological sites; it appears to grow best on the silty sites and grow poorer on the sandy and shallow sites. The mean flower stalk height reached during July was, 8.4 cm (3.3 in) on the sandy sites, 8.0 cm (3.2 in) on the silty sites, and 6.9 cm (2.7 in) on the clayey sites, and 5.9 cm (2.3 in) on the shallow sites. The mean flower stalk height on the shallow sites was significantly shorter than that on the silty sites. The heights on the other ecological sites were not significantly different. The percentage of flower stalks that had passed through the anthesis phenological growth stages was 33.4% by early June, 36.6% by late June, 76.3% by early July, and 99.8% by late July. Flowers were observed from early June to mid July on the sandy and clayey sites and from early June to late July on the shallow and silty sites of the 1984-1985 study. The mean flower stalk weights were 0.05 g on the sandy sites, 0.03 g on the silty sites, 0.02 g on the shallow sites, and 0.02 g on the clayey sites. The flower stalks on the sandy sites were significantly heavier than those on the shallow, silty, and clayey sites which were not significantly different.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. All of the plant communities on all management treatments greatly improved in species composition and plant density in a few years after the start of the studies in 1983. The presence of Wooly plantain greatly decreased on the sandy sites. Patterns in the changes in Wooly plantain abundance was followed for 30 growing seasons during the 1983-2012 study on the shallow and silty ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 7, 8, and 9).

Wooly plantain develops from seed as a winter annual or annual depending on when it germinates; in the fall or in the spring. Precipitation amounts above average were evaluated for September, October, April and May during the 30 growing seasons of 1983-2012 (Manske 2016). Wooly plantain was present during 23 growing seasons and not present during 7 growing seasons. During 13 growing seasons that Wooly plantain was present, the previous September and/or October and the current April and/or May had above average precipitation. During 6 growing seasons that Wooly plantain was present, the previous September and/or October had above average precipitation and the current April and May did not have above average precipitation. During 4 growing seasons that Wooly plantain was present, the previous September and October did not have above average precipitation and the current April and/or May had above average precipitation. During 5 growing seasons that Wooly plantain was not present, the previous September and October and the current April and May had below average precipitation. The 1988 growing season was one of these growing seasons void of Wooly plantain. During 1 other growing season that Wooly plantain was not present, the previous September and October had well below average precipitation and the current April had above average precipitation, but the spring conditions could not overcome the conditions of the previous dry fall. One growing season that Wooly plantain was not present was an anomaly to the previous conditions; the previous September and the current April both had above average precipitation, however, no Wooly plantain plants were present on the study sites.

Wooly plantain was present during 23 growing seasons (76.7%). During 19 of these growing seasons (82.6%), the Wooly plantain seeds had germinated during the previous fall and were winter annuals. During 4 of these growing seasons (17.4%), the Wooly plantain seeds had germinated during the current spring and were annuals. The biennial growth form was not detected during any of the DREC studies. During the 1984-1985 study, less than 0.2% of the Wooly plantain plants had not produced flowers by late July and by early August, 100.0% of the plants had produced flowers or had completely dried up and were undetectable.

On the shallow site of the nongrazed treatment, Wooly plantain was present during 5.3% and 3.8% of the years that density and basal cover data were collected with a mean 0.30 stems/m^2

density and a mean 0.004% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was not present where density data were collected and was present during 16.7% of the years that basal cover were collected with a mean 0.02% basal cover. During the later period (1998-2012), Wooly plantain was present during 7.1% of the years density were collected with a mean 0.34 stems/m^2 density and was not present where basal cover data were collected. The percent present was low, stem density increased, and basal cover decreased on the shallow site of the nongrazed treatment over time (tables 7, 8, and 9).

On the shallow site of the ungrazed seasonlong treatment, Wooly plantain was not present where basal cover data were collected and was present during 15.0% of the years that density were collected with a mean 0.09 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Wooly plantain was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Wooly plantain was present during 20.0% of the years density data were collected with a mean 0.12 stems/m^2 density. The percent present was low and stem density increased slightly on the shallow site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed seasonlong treatment, Wooly plantain was present during 40.0% and 7.7% of the years that density and basal cover data were collected with a mean 0.23 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was not present on the shallow site of the grazed seasonlong treatment. During the later period (1998-2012), Wooly plantain was present during 53.3% and 6.7% of the years with a mean 0.31 stems/m^2 density and a mean 0.001% basal cover, respectively. The percent present, stem density, and basal cover increased slightly on the shallow site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were slightly greater on the shallow site of the grazed seasonlong treatment than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Wooly plantain was present during 50.0% and 3.5% of the years that density and basal cover data were collected with a mean 0.19 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 42.9% of the years density data were collected with a mean 0.27 stems/m^2 density and was not present during the years that basal cover data were collected. During the later period (1998-2012), Wooly plantain was present during 53.3% and 6.7% of the years with a mean 0.15 stems/m^2 density and a mean 0.001% basal cover, respectively. The percent present, stem density, and basal cover all increased slightly on the shallow site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed twice-over treatment, Wooly plantain was present during 63.6% and 13.3% of the years that density and basal cover data were collected with a mean 0.85 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 28.6% of the years density data were collected with a mean 0.06 stems/m^2 density and was not present during the years basal cover data were collected. During the later period (1998-2012), Wooly plantain was present during 80.0% and 13.3% of the years with a mean 1.22 stems/m^2 density and a mean 0.002% basal cover, respectively. The percent present, stem density, and basal cover increased a little on the shallow site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present, stem density and basal cover were slightly greater on the shallow site of the grazed twice-over treatment than those on the shallow site of the ungrazed twice-over treatment.

During the 30 year period, percent present, stem density, and basal cover were remarkably low on the shallow sites of the nongrazed, ungrazed and grazed seasonlong, and ungrazed and grazed twice-over treatments.

On the silty site of the nongrazed treatment, Wooly plantain was not present where basal cover data were collected, and was present during 15.8% of the years density data were collected with a mean 0.08 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Wooly plantain was not present on the silty site of the nongrazed treatment. During the later period (1998-2012), Wooly plantain was present during 21.4% of the years that density data were collected with a mean 0.11 stems/m^2 density. Wooly plantain was not abundant on the silty site of the nongrazed treatment (tables 7, 8, and 9).

On the silty site of the ungrazed seasonlong treatment, Wooly plantain was present during 60.0% and 15.4% of the years that density and basal cover

data were collected with a mean 1.24 stems/m^2 density and a mean 0.014% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 60.0% and 16.7% of the years with a mean 2.92 stems/m^2 density and a mean 0.005% basal cover, respectively. During the later period (1998-2012), Wooly plantain was present during 60.0% and 13.3% of the years with a mean 0.68 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present and basal cover remained about the same and stem density decreased on the silty site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the silty site of the grazed seasonlong treatment, Wooly plantain was present during 75.0% and 30.8% of the years that density and basal cover data were collected with a mean 2.94 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 60.0% and 66.7% of the years with a mean 2.40 stems/m^2 density and a mean 0.12% basal cover, respectively. During the later period (1998-2012), Wooly plantain was present during 80.0% and 13.3% of the years with a mean 3.11 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present of density data and stem density increased and the percent present of basal cover data and basal cover decreased on the silty site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present and basal cover were similar and the stem density was a little greater on the silty site of the grazed seasonlong treatment than those on the silty site of the ungrazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, Wooly plantain was present during 45.5% and 31.0% of the years that density and basal cover data were collected with a mean 0.51 stems/m^2 density and a mean 0.012% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 57.1% and 44.4% of the years with a mean 1.11 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Wooly plantain was present during 40.0% and 20.0% of the years with a mean 0.23 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the silty site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the silty site of the grazed twice-over treatment, Wooly plantain was present during 77.3% and 50.0% of the years that density and basal cover data were collected with a mean 5.01 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Wooly plantain was present during 71.4% and 30.0% of the years with a mean 1.73 stems/m^2 density and a mean 0.04% basal cover, respectively. During the later period (1998-2012), Wooly plantain was present during 80.0% and 60.0% of the years with a mean 6.55 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present and stem density increased and basal cover decreased on the silty site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the silty site of the grazed twice-over treatment than those on the silty site of the ungrazed twice-over treatment.

During the 30 year period, stem density and basal cover of Wooly plantain were lower on the silty sites of the nongrazed, ungrazed seasonlong and ungrazed twice-over treatments than those on the silty sites of the grazed seasonlong and grazed twice-over treatments. This would indicate that shading caused some problems for successful development of Wooly plantain seedlings. The stem density was greater on the silty site of the grazed twice-over treatment than that on the silty site of the grazed seasonlong treatment. The basal cover was greater on the silty site of the grazed seasonlong treatment than that on the silty site of the grazed twice-over treatment.

Discussion

Wooly plantain, *Plantago patagonica*, is a late succession native winter annual and sometimes annual forb of the plantain family that is commonly present on healthy mixed grass prairie plant communities when the previous September and/or October and/or the current April and/or May had above average precipitation. Wooly plantain can grow on sandy, shallow, silty, and clayey ecological sites. It appears to grows best on the silty ecological sites. Wooly plantain was present during 34.8% and 5.7% of the years density and basal cover data were collected on the shallow ecological sites with a mean 0.33 stems/m^2 density and a mean 0.004% basal cover, respectively. Wooly plantain was present during 54.7% and 25.4% of the years density and basal cover data were collected on the silty ecological sites with a mean 1.96 stems/m^2 density and a mean 0.02% basal cover, respectively.

Early growth after seed germination during the fall or spring develops a rosette of small basal

leaves on a crown with a short taproot. Later aerial growth produces a rosette of larger basal leaves. A dense cylindrical inflorescence develops on a leafless scape. No stems are produced. The mean first flower data was 11 July (1955-1962 study) with a four week flower period from early June to late June (1969-1971 study) with observed flowers occurring from early June through late July and perhaps into early August (1984-1985 study). Mean flower stalk height was 14.0 cm (5.5 in) (1955-1962 study) and was 7.3 cm (2.9 in) (1984-1985 study). Mean stem weight was 0.03 g (1984-1985 study).

Wooly plantain contributes little to plant herbage biomass. At a mean high density of 2.0 stems/m^2 with a mean weight of 0.03 g/stem: 0.06g/m^2 = 0.60 kg/ha and 0.54 lbs/ac.

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Table 1. First flower and flower period of Plantago patagonica, Wooly plantain.

	Apr	May	Jun		Jul	Aug	Sep
First Flower							
1955-1962							
Earliest			18				
Mean					11		
Flower Period							
1969-1971			XX	XX			

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

Table 2. Autecology of Plantago patagonica, Wooly plantain, 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	9.0	22.0	14.0			68.6	100.0		

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Plantago patagonica, Wooly plantain, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	4.8	13.7				
Bud	76.2	54.8	25.3			
Anth	14.3	2.7	16.0			
Seed Dev	4.8	17.8	44.0	63.3	43.1	
Seed Shed		9.6	13.3	30.0	51.0	78.6
Mat		1.4	1.3	6.7	5.9	21.4
Mean Height (cm)						
Veg	7.0	1.5				
Bud	6.4	6.7	5.7			
Anth	7.8	7.2	7.8			
Seed Dev	6.4	8.2	7.8	8.6	9.8	
Seed Shed		6.8	7.1	10.5	7.6	8.6
Mat		2.9	5.1	4.9	7.7	7.1
% Dryness						
Veg	2.0	0.0				
Bud	0.3	0.3	3.4			
Anth	0.0	0.0	3.3			
Seed Dev	0.0	68.8	33.2	51.9	60.9	
Seed Shed		85.4	94.0	81.6	84.0	100.0
Mat		100.0	100.0	93.3	100.0	100.0
Mean Weight (g)	0.04	0.05	0.05	0.06	0.04	0.04

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 4. Phenological growth stage changes during the growing season for Plantago patagonica, Wooly plantain, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg		14.1	1.0			
Bud	70.6	53.5	14.4			
Anth	29.4	2.8	15.4	1.2		
Seed Dev		8.5	47.1	31.7	32.7	8.1
Seed Shed		19.7	18.3	53.7	46.9	81.1
Mat		1.4	3.8	13.4	20.4	10.8
Mean Height (cm)						
Veg		0.9	0.4			
Bud	6.3	5.0	5.5			
Anth	6.1	2.3	5.4	4.3		
Seed Dev		12.0	4.9	6.8	7.0	11.9
Seed Shed		5.0	6.7	7.4	7.2	7.3
Mat		3.5	5.2	5.0	5.4	5.6
% Dryness						
Veg		0.2	0.0			
Bud	0.9	0.2	2.9			
Anth	0.1	1.0	5.8	25.0		
Seed Dev		58.7	27.0	59.6	74.6	100.0
Seed Shed		64.0	95.7	90.6	92.2	100.0
Mat		100.0	99.5	99.8	99.6	100.0
Mean Weight (g)	0.02	0.01	0.02	0.02	0.03	0.03

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 5. Phenological growth stage changes during the growing season for Plantago patagonica, Wooly plantain, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	1.6	6.9	5.8			
Bud	53.2	48.3	20.9	0.7		
Anth	27.4	4.1	11.6			
Seed Dev	17.7	22.8	34.3	37.2	20.4	
Seed Shed		15.9	20.3	47.6	59.9	89.4
Mat		2.1	7.0	14.5	19.7	10.6
Mean Height (cm)						
Veg	6.1	1.1	5.6			
Bud	6.6	7.6	7.9	1.2		
Anth	6.9	8.1	7.9			
Seed Dev	8.6	7.9	8.0	9.0	10.2	
Seed Shed		7.5	6.8	8.5	8.4	8.1
Mat		4.5	4.9	6.4	6.6	7.3
% Dryness						
Veg	0.0	0.0	89.6			
Bud	0.2	0.7	1.8	2.0		
Anth	0.2	4.5	2.2			
Seed Dev	2.5	47.8	34.6	58.1	73.7	
Seed Shed		72.8	93.9	93.1	97.3	99.7
Mat		100.0	99.5	99.9	99.8	100.0
Mean Weight (g)	0.02	0.01	0.04	0.03	0.03	0.03

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 6. Phenological growth stage changes during the growing season for Plantago patagonica, Wooly plantain, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg		7.1	15.0			
Bud	60.0	55.3	12.1			
Anth	36.7	10.6	46.7			
Seed Dev	3.3	25.9	17.8	45.3	9.6	5.8
Seed Shed		1.2	8.4	35.9	57.5	71.0
Mat				18.8	32.9	23.2
Mean Height (cm)						
Veg		2.0				
Bud	5.2	5.2	7.1			
Anth	4.6	5.9	7.6			
Seed Dev	3.5	5.5	7.1	7.5	9.5	10.8
Seed Shed		6.1	6.5	5.7	6.4	8.0
Mat			6.4	5.5	5.5	5.5
% Dryness						
Veg		4.2				
Bud	0.3	2.4	2.3			
Anth	0.2	8.6	0.9			
Seed Dev	0.0	43.3	35.4	48.3	85.4	98.0
Seed Shed		75.0	92.7	87.7	91.2	99.9
Mat			88.4	100.0	96.7	100.0
Mean Weight (g)	0.01	0.02	0.02	0.02	0.01	0.02

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 7. Autecology of Plantago patagonica, Wooly plantain, with growing season changes in density importance value, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	0.00	0.00	0.00	1.31	0.39
1988-1992	0.00	0.00	0.00	0.94	0.18
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	1.18	0.00	0.14	0.53	4.39
2004-2009	0.00	0.84	2.11	0.77	6.54
2010-2012	0.00	0.00	2.65	0.10	0.86
Silty					
1983-1987	0.00	12.65	21.90	4.15	2.60
1988-1992	0.00	7.50	9.60	3.93	5.73
1993-1998	0.00	0.00	0.77	0.00	0.00
1999-2003	0.00	1.64	1.91	0.98	9.67
2004-2009	0.80	5.64	7.00	0.22	21.15
2010-2012	0.41	0.49	9.15	3.67	8.66

Table 8. Autecology of Plantago patagonica, Wooly plantain, with growing season changes in basal cover importance value, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.16	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.53	0.00	0.26
1999-2003	0.00	0.00	0.00	0.00	0.01
2004-2009	0.00	0.00	0.02	0.02	0.02
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.33	1.47	0.09	0.11
1988-1992	0.00	0.00	0.61	0.27	0.36
1993-1998	0.00	0.41	0.86	0.10	0.41
1999-2003	0.00	0.08	0.00	0.03	0.11
2004-2009	0.00	0.05	0.08	0.04	0.16
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 9. Autecology of Plantago patagonica, Wooly plantain, with growing season changes in density, 1983-					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	Few Plants Present				
1988-1992					
1993-1998					
1999-2003					
2004-2009					
2010-2012					
Shallow					
1983-1987	0.00	0.00	0.00	0.03	0.01
1988-1992	0.00	0.00	0.00	0.02	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.12	0.00	0.00	0.02	0.10
2004-2009	0.00	0.03	0.05	0.02	0.21
2010-2012	0.00	0.00	0.05	0.00	0.02
Silty					
1983-1987	0.00	0.52	0.72	0.12	0.09
1988-1992	0.00	0.24	0.12	0.10	0.23
1993-1998	0.00	0.00	0.03	0.00	0.00
1999-2003	0.00	0.04	0.06	0.01	0.22
2004-2009	0.02	0.13	0.65	0.01	1.38
2010-2012	0.01	0.01	0.16	0.09	0.15

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