Autecology of Small Leaf Pussytoes on the Northern Mixed Grass Prairie

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The autecology of Small Leaf Pussytoes, *Antennaria parvifolia*, 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).

Small Leaf Pussytoes, *Antennaria parvifolia* Nutt., is a member of the aster (sunflower) family, Asteraceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bergman 1910. Early annual aerial growth is a mat of simple, alternate basal leaves narrowly spatulate or oblanceolate, 2-5 cm (0.8-2.0 in) long, arising from an extensive stolon system with enlarged root crowns (caudex) at nodes with basal leaves. The entire plant is densely covered with hairs. The root system has vertical and horizontal fibrous roots spreading from root crowns and stolen nodes. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the crown and by sprouts from nodes on the extensive stolen system. Inflorescence is a large closely aggregated cyme with 2 to 6 heads on a flower stalk 5-15 cm (2.0-5.9 in) tall appearing during late May to late June. Male and female parts are on different plants (dioecious) with some seed production occurring without sexual fertilization (apomixis). Flower stalk leaves are small, linear to narrowly oblanceolate reducing upwards. Fruits are small achene with pappus of bristles. Aerial parts are not eaten by livestock and are top killed by fire including the stolens. Damage to aerial parts activates regrowth shoots from the crown and from any surviving segments of the stolen. This summary information on growth development and regeneration of small leaf pussytoes was based on the works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Johnson and Larson 2007, and Fryer 2011.

Procedures

The 1955-1962 Study

Small leaf pussytoes 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 Small leaf pussytoes 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

Small leaf pussytoes 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 12 ungrazed specimens randomly selected on each of the 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 30 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 Small leaf pussytoes 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 Small leaf pussytoes 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 that 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 values 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

Small Leaf Pussytoes resumed early spring growth as a mat of rosettes of basal leaves from an extensive stolen system. The plant stems, which are the flower stalks, appear during May and June. On the fall grazed pasture of the 1955-1962 study, the earliest first flowers appeared 22 May, the mean first flowers occurred on 10 June, and the flower period, from the 1969-1971 study, extended from late May to late June (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature flower stalk height of 9.0 cm (3.5 in) with an annual variance in height from 6.0 cm (2.4 in) to 11.0 cm (4.3 in) was reached during June (table 2) (Goetz 1963). The reported normal mature stalk

height ranged from 5 cm to 15 cm (2.0 to 5.9 in), whereas the range of mature stalk heights of 6.0 cm to 11.0 cm (2.4 to 4.3 in) from the 1955-1962 study were in the shorter portion of the normal height range. The lower heights of Small leaf pussytoes 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.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 3,807 Small leaf pussytoes stems were sampled during this study, with 957 stems (25.14%) from the sandy sites, 1034 stems (27.16%) from the shallow sites, 1034 stems (27.16%) from the silty sites, and 782 stems (20.54%) from the clayey sites. Small leaf pussytoes can grow on the sandy, shallow, silty, and clayey ecological sites, but, appears to do better on the shallow and silty ecological sites.

The range of mean mature stalk heights was 5.9 cm to 9.9 cm (2.3 to 3.9 in) for the 1984-1985 study, was similar to the range of mature stalk heights on the 1955-1962 study, and were also in the shorter portion of the normal height range. The reduced stalk height of Small leaf pussytoes on the 1984-1985 study was caused by low quantities of available mineral nitrogen below the threshold levels of 100 lbs/ac that resulted from the traditional management practices conducted prior to the start of this study.

During the growing season, most of the Small leaf pussytoes plant material remained at the vegetative growth stage of rosette basal leaves with, 91.7% on the sandy sites, 91.3% on the shallow sites, 95.2% on the silty sites, and 91.8% on the clayey sites (tables 3, 4, 5, and 6).

Mean Small leaf pussytoes stem weights were not significantly different on the four ecological sites. Stem weights were heaviest on the shallow and silty sites at 0.22 g each, and were lightest on the clayey and sandy sites at 0.18 g and 0.17 g, respectively (tables 3, 4, 5, and 6).

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Aerial plant parts of Small leaf pussytoes are unpalatable and too short to be eaten by livestock. The changes in plant abundance are not directly caused by partial defoliation by grazing. The plant abundance was low on the three ecological sites; it was considerably lower on the sandy site than on the shallow and silty sites. During the 1983-2012 study, the pattern of plant abundance change was similar on the three ecological sites and on the three management treatments. Small leaf pussytoes plant abundance was low during the entire 30 year (1983-2012) study. Plant abundance was greater during the early period (1983-1987) when the growing season precipitation (April -October) was 13.59 inches (96.18% of the long-term mean). Plant abundance greatly decreased during the low precipitation period (1988-1992) when growing season precipitation was 9.65 inches (68.29% of the long-term mean). A few sites had some remnant Small leaf pussytoes plants that continued to decrease during the period (1993-1996), following the drought period, when the growing season precipitation had increased to 13.63 inches (96.48% of the long-term mean). Grass plant recovery was relatively rapid and grass density was increasing greatly. During the later period (1998-2012), growing season precipitation was above average at 15.25 inches (107.93% of the long-term mean), grass abundance remained high and the occurrence of Small leaf pussytoes was quite sparse.

On the sandy site of the nongrazed treatment, Small leaf pussytoes was present during 0.0% and 8.0% of the years that density and basal cover data were collected, with a mean 0.003% basal cover. During the early period (1983-1992), Small leaf pussytoes was present during 0.0% and 20.0% of the years, with a mean 0.01% basal cover. During the later period (1998-2012), Small leaf pussytoes was present 0.0% and 0.0% of the years that density and basal cover data were collected, respectively. Plant species presence of Small leaf pussytoes was completely eliminated during the later period on the sandy site of the nongrazed treatment (tables 7, 8, and 9).

On the sandy sites of the seasonlong treatment, Small leaf pussytoes was present on the ungrazed sandy site during 0.0% and 0.0% of the years, and was present on the grazed sandy site during 5.3% and 12.0% of the years that density and basal cover data were collected, with a mean 0.01 stems/m^2 density and a mean 0.01% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed sandy site during 0.0% and 0.0% of the years, and was present on the grazed sandy site during 25.0% and 40.0% of the years, with a mean 0.03 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed sandy site during 0.0% and 0.0% of the years, and was present on the grazed sandy site during 0.0% and

0.0% of the years that density and basal cover data were collected. Plant species presence of Small leaf pussytoes was completely eliminated during the later period on the ungrazed and grazed sandy sites of the seasonlong treatment (tables 7, 8, and 9).

On the sandy sites of the twice-over treatment, Small leaf pussytoes was present on the ungrazed sandy site during 9.5% and 20.7% of the years, with a mean 0.06 stems/m^2 density and a mean 0.02% basal cover, and was present on the grazed sandy site during 14.3% and 27.6% of the years that density and basal cover data were collected, with a mean 0.15 stems/m^2 density and a mean 0.02% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed sandy site during 33.3% and 66.7% of the years, with a mean 0.22 stems/m^2 density and a mean 0.05% basal cover, and was present on the grazed sandy site during 33.3% and 88.9% of the years, with a mean 0.50 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed sandy site during 0.0% and 0.0% of the years, and was present on the grazed sandy site during 6.7% and 0.0% of the years, with a mean 0.01 stems/m^2 density, respectively. Plant species presence of Small leaf pussytoes was completely eliminated on the ungrazed sandy site and was nearly eliminated on the grazed sandy site of the twice-over treatment during the later period (1998-2012) (tables 7, 8, and 9).

On the shallow site of the nongrazed treatment, Small leaf pussytoes was present during 0.0% and 3.8% of the years that density and basal cover data were collected, with a mean 0.001% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present during 0.0% and 16.7% of the years, with a mean 0.005% basal cover. During the later period (1998-2012), Small leaf pussytoes was present during 0.0% and 0.0% of the years. Plant species presence of Small leaf pussytoes was completely eliminated during the later period on the shallow site of the nongrazed treatment (tables 7, 8, and 9).

On the shallow sites of the seasonlong treatment, Small leaf pussytoes was present on the ungrazed shallow site during 5.0% and 0.0% of the years, with a mean 0.02 stems/m^2 density, and was present on the grazed shallow site during 20.0% and 7.7% of the years that density and basal cover data were collected, with a mean 0.25 stems/m^2 density and a mean 0.007% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed shallow site during 0.0% and 0.0% of the years, and was present on the grazed shallow site during 40.0% and 16.7% of the years, with a mean 0.96 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed shallow site during 6.7% and 0.0% of the years, with a mean 0.03 stems/m^2 density, and was present on the grazed shallow site during 13.3% and 0.0% of the years, with a mean 0.01 stems/m^2 density. Plant species presence of Small leaf pussytoes was nearly eliminated during the later period on the ungrazed and grazed shallow site of the seasonlong treatment (tables 7, 8, and 9).

On the shallow sites of the twice-over treatment, Small leaf pussytoes was present on the ungrazed shallow site during 22.7% and 30.0% of the years, with a mean 0.17 stems/m^2 density and a mean 0.04% basal cover, and was present on the grazed shallow site during 22.7% and 26.7% of the years that density and basal cover data were collected, with a mean 0.10 stems/m^2 density and a mean 0.02% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed shallow site during 42.9% and 70.0% of the years, with a mean 0.44 stems/m^2 density and a mean 0.12% basal cover, and was present on the grazed shallow site during 71.4% and 60.0% of the years, with a mean 0.33 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed shallow site during 13.3% and 6.7% of the years, with a mean 0.04 stems/m^2 density and a mean 0.002% basal cover, and was present on the grazed shallow site during 0.0% and 0.0% of the years, respectively. Plant species presence of Small leaf pussytoes was nearly eliminated on the ungrazed shallow site and was completely eliminated on the grazed shallow site of the twice-over treatment during the later period (1998-2012) (tables 7, 8, and 9).

On the silty site of the nongrazed treatment, Small leaf pussytoes was present during 5.3% and 7.7% of the years that density and basal cover data were collected, with a mean 0.02 stems/m^2 density and a mean 0.002% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present during 20.0% and 0.0% of the years, with a mean 0.08 stems/m^2 density. During the later period (1998-2012), Small leaf pussytoes was present during 0.0% and 6.7% of the years, with a mean 0.002% basal cover, respectively. Plant species presence of Small leaf

pussytoes was nearly eliminated on the silty site of the nongrazed treatment during the later period (1998-2012) (tables 7, 8, and 9).

On the silty sites of the seasonlong treatment, Small leaf pussytoes was present on the ungrazed silty site during 5.0% and 3.8% of the years, with a mean 0.18 stems/m^2 density and a mean 0.01% basal cover, and was present on the grazed silty site during 5.0% and 15.4% of the years that density and basal cover data were collected, with a mean 0.08 stems/m^2 density and a mean 0.02% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed silty site during 20.0% and 16.7% of the years, with a mean 0.70 stems/m^2 density and a mean 0.05% basal cover, and was present on the grazed silty site during 20.0% and 50.0% of the years, with a mean 0.30 stems/m^2 density and a mean 0.06% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed silty site during 0.0% and 0.0% of the years, and was present on the grazed silty site during 0.0% and 0.0% of the years that density and basal cover data were collected. Plant species presence of Small leaf pussytoes was completely eliminated during the later period on the ungrazed and grazed silty sites of the seasonlong treatment (tables 7, 8, and 9).

On the silty sites of the twice-over treatment, Small leaf pussytoes was present on the ungrazed silty site during 13.6% and 16.7% of the years, with a mean 0.18 stems/m^2 density and a mean 0.03% basal cover, and was present on the grazed silty site during 18.2% and 20.0% of the years that density and basal cover data were collected, with a mean 0.19 stems/m^2 density and a mean 0.05% basal cover during the total period, respectively. During the early period (1983-1992), Small leaf pussytoes was present on the ungrazed silty site during 42.9% and 40.0% of the years, with a mean 0.57 stems/m^2 density and a mean 0.09% basal cover, and was present on the grazed silty site during 57.1% and 60.0% of the years, with a mean 0.59 stems/m^2 density and a mean 0.14% basal cover, respectively. During the later period (1998-2012), Small leaf pussytoes was present on the ungrazed silty site during 0.0% and 0.0% of the years, and was present on the grazed silty site during 0.0% and 0.0% of the years that density and basal cover data were collected. Plant species presence of Small leaf pussytoes was completely eliminated during the later period on the ungrazed and grazed silty sites of the twice-over treatment (tables 7, 8, and 9).

Small leaf pussytoes was present on the management treatment areas prior to the start of the 1983-2012 study as a result of the detrimental effects caused by the previously used traditional management practices that caused the quantities of available mineral nitrogen to decrease below the threshold levels of 100 lbs/ac reducing plant density and increasing the number and size of open spaces in the plant communities. Small leaf pussytoes was able to move in and occupy some of those spaces. The low precipitation conditions during the period of 1988 to 1992 caused the demise of most of the Small leaf pussytoes plants. Then during the later period (1998-2012) when growing season precipitation was greater than average, the competition from healthy, dense grass plant communities nearly or completely eliminated the Small leaf pussytoes plants. Small leaf pussytoes were nearly eliminated during the later period (1998-2012) from the silty site of the nongrazed treatment, from the ungrazed and grazed shallow sites of the seasonlong treatment, and from the ungrazed shallow site and the grazed sandy site of the twice-over treatment. Small leaf pussytoes were completely eliminated during the later period (1998-2012) from the sandy and shallow sites of the nongrazed treatment, from the ungrazed and grazed sandy and silty sites of the seasonlong treatment, and from the ungrazed sandy and silty sites and the grazed shallow and silty sites of the twice-over treatment.

Discussion

Small Leaf Pussytoes, *Antennaria parvifolia*, is a small late succession forb that is commonly present but a minor component of healthy mixed grass prairie plant communities. Small Leaf Pussytoes can grow in sandy, shallow, silty, and clayey ecological sites but does better growing in shallow and silty ecological sites. Annual aerial growth resumes in early spring as rosettes of basal leaves arising from enlarged root crowns (caudexes) of an extensive stolen system. The flower period (anthesis) occurs from late May to late June. Erect aerial stems (flower stalks) reach maximum mature height during June, however, only about 7.5% of the rosettes of basal leaves produce a flower stalk. Small leaf pussytoes is unpalatable and too short to be grazed by livestock, and thus the effects from partial defoliation by grazing do not directly cause annual changes in plant abundance, however, competition for sunlight and essential elements from the soil by healthy, dense grass plants can have serious consequences on pussytoes abundance. The normal mature stalk height of Small leaf pussytoes in the Northern Plains is reported to be between 5 cm and 15 cm (2-6 in). The stalk heights collected during the 1955-1962 study and the 1984-1985 study were at the short end of the normal mature flower stalk height

because the soils of both studies had quantities of mineral nitrogen available at less than the threshold quantity of 100 lbs/ac which resulted from the detrimental effects caused by traditional management practices on the biogeochemical processes and the soil microbe biomass of the prairie plant communities.

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Table 1. First flower and flower period of Antennaria parvifolia, Small Leaf Pussytoes.

	Apr	May	Jun		Jul	Aug	Sep
First Flower							
1955-1962							
Earliest		22					
Mean			10				
Flower Period							
1969-1971		X	XX	XX			

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

Table 2. Autecology of Antennaria parvifolia, Small Leaf Pussytoes, 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	6.0	11.0	9.0		77.9	100.0			

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for, Antennaria parvifolia, Small Leaf Pussytoes, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	96.8	85.2	93.3	87.3	89.7	97.6
Bud						
Anth						
Seed Dev						
Seed Shed	1.6	10.4	4.9	11.3	8.2	0.8
Mat	1.6	4.4	1.8	1.3	2.1	1.6
Mean Height (cm)						
Veg	4.2	2.7	1.7	2.7	2.4	2.5
Bud						
Anth						
Seed Dev						
Seed Shed	4.9	4.9	6.2	7.9	12.0	8.9
Mat	4.9	8.1	8.1	6.1	10.8	6.2
% Dryness						
Veg	8.7	16.2	8.6	17.9	23.5	28.3
Bud						
Anth						
Seed Dev						
Seed Shed	25.0	36.1	71.1	45.6	57.7	2.0
Mat	50.0	37.5	16.7	100.0	75.0	50.0
Mean Weight (g)	0.23	0.15	0.22	0.17	0.12	0.14

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, Antennaria parvifolia, Small Leaf Pussytoes, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	83.1	89.9	86.1	93.2	95.7
Bud						
Anth						
Seed Dev						
Seed Shed		7.5	2.4	13.9	4.8	2.2
Mat		9.4	7.7		2.1	2.2
Mean Height (cm)						
Veg	3.2	2.1	2.1	2.2	2.6	2.4
Bud						
Anth						
Seed Dev						
Seed Shed		5.9	6.2	5.2	7.2	6.3
Mat		6.2	6.8		3.1	6.8
% Dryness						
Veg	7.9	10.7	21.8	21.5	27.3	31.5
Bud						
Anth						
Seed Dev						
Seed Shed		13.5	44.3	78.9	32.1	75.0
Mat		56.1	31.6		58.3	91.0
Mean Weight (g)	0.29	0.22	0.17	0.19	0.23	0.23

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, Antennaria parvifolia, Small Leaf Pussytoes, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	96.4	94.6	94.1	90.1	95.7
Bud						
Anth						
Seed Dev		0.7				
Seed Shed		2.2	3.6	4.4	9.9	4.3
Mat		0.7	1.8	1.5		
Mean Height (cm)						
Veg	3.2	2.7	2.3	2.5	2.4	2.6
Bud						
Anth						
Seed Dev		10.1				
Seed Shed		6.4	8.7	7.9	5.8	6.0
Mat		7.5	10.6	8.2		
% Dryness						
Veg	6.8	10.2	12.0	20.5	29.6	35.3
Bud						
Anth						
Seed Dev		2.0				
Seed Shed		2.0	34.0	62.5	39.6	64.3
Mat		75.0	41.7	75.0		
Mean Weight (g)	0.27	0.13	0.17	0.23	0.22	0.31

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, Antennaria parvifolia, Small Leaf Pussytoes, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	96.6	92.2	88.5	85.9	91.9	95.7
Bud						
Anth						
Seed Dev						
Seed Shed	1.7	5.2	6.6	14.1	4.0	4.3
Mat	1.7	2.6	4.9		4.0	
Mean Height (cm)						
Veg	3.5	2.0	2.2	2.5	2.8	2.4
Bud						
Anth						
Seed Dev						
Seed Shed	12.1	8.3	7.7	7.7	7.2	8.7
Mat	11.5	9.0	10.5		6.6	
% Dryness						
Veg	5.5	9.8	15.8	22.8	24.9	35.3
Bud						
Anth						
Seed Dev						
Seed Shed	25.0	13.5	22.6	62.1	62.0	86.5
Mat	50.0	41.7	26.0		63.2	
Mean Weight (g)	0.24	0.10	0.14	0.22	0.16	0.19

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

Table 7. Autecology of Antennaria parvifolia, Pussytoes, 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	2.83	5.38
1988-1992	0.00	0.00	0.56	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	0.12
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	17.11	3.17	2.16
1988-1992	0.00	0.00	3.39	0.00	1.47
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	1.29	0.56	0.00	0.00
2004-2009	0.00	0.00	0.00	0.11	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	2.93	5.44	5.03	2.27	3.67
1988-1992	0.00	0.00	0.00	0.00	0.73
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

Table 8. Autecology of Antennaria parvifolia, Pussytoes, with growing season changes in basal cover importance value, 1983-2012.

Ecological Site Ten Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.48	0.00	1.28	0.61	0.64
1988-1992	0.00	0.00	0.11	0.08	0.31
1993-1998	0.07	0.00	0.08	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
Shallow					
1983-1987	0.00	0.00	0.91	1.61	0.54
1988-1992	0.00	0.00	0.00	0.40	0.12
1993-1998	0.06	0.00	0.04	0.06	0.13
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.00	0.00	0.00	0.03	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	2.03	1.57	0.97	1.74
1988-1992	0.00	0.00	0.13	0.00	0.17
1993-1998	0.16	0.00	0.18	0.04	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

Table 9. Autecology of Antennaria parvifolia, Pussytoes, 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	0.04	0.10
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	0.04
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.33	0.10	0.07
1988-1992	0.00	0.00	0.04	0.00	0.01
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.01	0.00	0.00	0.00
2004-2009	0.00	0.00	0.00	0.04	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.04	0.35	0.15	0.10	0.12
1988-1992	0.00	0.00	0.00	0.00	0.01
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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