Autecology of Hood's Phlox on the Northern Mixed Grass Prairie

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The autecology of Hood's phlox*, Phlox hoodii,* 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).

Hood's phlox*, Phlox hoodii* Richardson, is member of the phlox (polemonium) family, Polemoniaceae, and is a native, perennial, early cool season, dicot, herb that have highly variable botanical characteristics. The first North Dakota record is Bolley 1891. Annual aerial growth has numerous branching stems in compact dense tufts (caespitose) forming moss like mats 10-30 cm (3.9-11.8 in) wide, 2.5-5.1 cm (1-2 in) tall arising from a persistent woody root crown (caudex). Leaves are opposite, simple, awl shaped (subulate) 4-10 mm long, 1 mm wide, with a thick mid rib and a rigid shape point that has a bitter, biting (acrid) odor and taste; the leaves are dense, ascending, and overlapping, and the older leaves are persistent with a slow turnover. Stems and leaves are woolly to loosely pubescent. The roots system consists of a main coarse woody taproot that develops from the crown that can descend to 95 cm (37 in) in loose deep prairie soil, to 41 cm (16 in) in sandy soil, and to 30 cm (12 in) in shallow soil. The taproot has short lateral roots less than 2 cm (0.8 in) long that occur singly or in groups of 2 to 5 at soil depths below 10 cm (4 in). Occasionally 1 or 2 large secondary taproots are produced that can descend as deep as the primary taproot. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprout from the subterrranian crown and by regrowth shoots from the crown following damage to aerial stems. Flowers are terminal, solitary, sessile at branch tips with 5 showy white to lavender petals that appear in early spring during early May to mid June. Pollination is by butterflies and bees. Seeds are small, 2-3 mm long. Aerial parts are not eaten by livestock and are top killed by fire. Damage to aerial stems activates regrowth shoots from the crown. This summary information on growth development and regeneration of Hood's phlox was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Gucker 2006, and Johnson and Larson 2007.

Procedures

The 1955-1962 Study

Hood's phlox 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 Hood's phlox 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

Hood's phlox 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 54 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 11 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 Hood's phlox 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 Hood's phox 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

Hood's phlox resumed growth in early spring as numerous branching stems arising from a persistent woody root crown with a deep coarse woody taproot with short lateral roots. The dense tufts of stems form moss like mats. The solitary white to lavender flowers are terminal at stem branch tips.

On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 28 April, the mean first flowers occurred on 24 May, and the 5 week flower period extended from early May to the end of the first week in June on the 1969-1971 study (table 1) (Goetz 1963, Zaczkowski 1972). The stems do not stand upright and remain close to the ground. A mean stem height of 4.6 cm (1.8 in) with an annual variance in height from 3.0 cm (1.2 in) to 6.0 cm (2.4 in) was reached during June (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 2.5 cm to 5.1 cm (1-2 in) tall. The stems measured during the 1955-1961 study were within the normal range to slightly taller than the height 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 3,110 Hood's phlox stems were sampled during this study with, 832 stems (26.8%) from the sandy sites, 954 stems (30.7%) from the shallow sites, 756 stems (24.3%) from the silty sites, and 568 stems (18.3%) from the clayey sites. Hood's phlox can grow on sandy, shallow, silty, and clayey ecological sites; it appears to grow best on the shallow sites. The mean mature height reached during June was, 4.8 cm (1.9 in) on the sandy sites, 5.3 cm (2.1 in) on the silty sites, and 5.1 cm (2.0 in) on the clayey sites and were not significantly different. The mean stem height of 3.6 cm (1.4 in) on the shallow sites was significantly shorter than those on the sandy, silty, and clayey ecological sites. The mean stem heights collected on the 1984-1985 study were within or near the normal stem heights for the Northern Plains. Mean Hood's phlox stem weights were, 0.50 g on the sandy sites, 0.37 g on the shallow sites, 0.34 g on the silty sites, and 0.27 g on the clayey sites, and were not significantly different (tables 3, 4, 5, and 6).

Most of the showy flowers of Hood's phlox appear during May. Some flowers appeared during the 1984-1985 study during early June on the shallow and silty sites, during late June on the sandy sites, and during early July on the silty sites. Flowers were not observed on the clayey sites. Many (44.5%) of the Hood's phlox stems were vegetative stems during the growing season.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Patterns in the changes in 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 7, 8, and 9).

On the sandy site of the nongrazed treatment, Hood's phlox was present during 38.9% and 40.0% of the years that density and basal cover data were collected, with a mean 0.53 stems/m^2 density and a mean 0.06% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Hood's phlox was present during 50.0% and 60.0% of the years with a mean 0.69 stems/m^2 density and a mean 0.09% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the nongrazed treatment over time (tables 7, 8, and 9).

On the sandy site of the ungrazed seasonlong treatment, Hood's phlox was not present during the 30 year period.

On the sandy site of the grazed seasonlong treatment, Hood's phlox was present during 47.4% and 28.0% of the years that density and basal cover data were collected with a mean 0.10 stems/m^2 density and a mean 0.04% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 25.0% and 20.0% of the years with a mean 0.03 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 13.3% and 13.3% with a mean 0.12 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present decreased and stem density and basal cover increased on the sandy site of the grazed seasonlong treatment over time (tables 7, 8, and 9). 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, Hood's phlox was present during 57.1% and 65.5% of the years that density and basal cover data were collected, with a mean 0.16 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 33.3% and 37.5% of the years with a mean 0.12 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 66.7% and 86.7% of the years with a mean 0.17 stems/m^2 density and a mean 0.03% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy

site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the sandy site of the grazed twice-over treatment, Hood's phlox was present during 76.2% and 82.8% of the years that density and basal cover data were collected with a mean 1.32 stems/m^2 density and a mean 0.12% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 33.3% and 55.6% of the years with a mean 0.13 stems/m^2 density and a mean 0.08% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 93.3% and 100.0% of the years with a mean 1.80 stems/m^2 density and a mean 0.12% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the grazed twice-over treatment (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the sandy site of the grazed twice-over treatment than those on the sandy site of the ungrazed twice-over treatment.

On the shallow site of the nongrazed treatment, Hood's phlox was present during 73.7% and 73.1% of the years that density and basal cover data were collected with a mean 1.53 stems/m^2 density and a mean 0.09% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's Phlox was present during 20.0% of the years density was collected with a mean 0.12 stems/m^2 density and was not present where basal cover data were collected. During the later period (1998-2012), Hood's phlox was present during 92.9% and 93.3% of the years with a mean 2.03 stems/m^2 density and a mean 0.09% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the nongrazed treatment over time (tables 7, 8, and 9).

On the shallow site of the ungrazed seasonlong treatment, Hood's phlox was present during 50.0% and 34.6% of the years that density and basal cover data were collected with a mean 0.86 stems/m^2 density and a mean 0.09% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Hood's phlox was present during 85.0% and 84.6% of the years with a mean 1.15 stems/m^2 density and a mean 0.15% basal cover, respectively. The percent present, stem density, and basal cover all increased 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, Hood's phlox was present during 90.0% and 96.2% of the years that density and basal cover data were collected with a mean 3.43 stems/m^2 density and a mean 0.38% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 60.0% and 83.3% of the years with a mean 0.64 stems/m^2 density and a mean 0.14% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years with a mean 4.35 stems/m^2 density and a mean 0.39% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover on the shallow site of the grazed seasonlong treatment were greater than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Hood's phlox was present during 86.4% and 96.6% of the years that density and basal cover data were collected with a mean 1.16 stems/m^2 density and a mean 0.18% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 57.1% and 88.9% of the years with a mean 1.61 stems/m^2 density and a mean 0.28% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years with a mean 0.94 stems/m^2 density and a mean 0.09% basal cover, respectively. The percent present increased and the stem density and basal cover decreased 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, Hood's phlox was present during 86.4% and 93.3% of the years that density and basal cover data were collected with a mean 6.35 stems/m^2 density and a mean 0.67% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 57.1% and 80.0% of the years with a mean 2.51 stems/m^2 density and a mean 0.50% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years with a mean 8.14 stems/m^2 density and a mean 0.75% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present was nearly the same on the shallow sites of the ungrazed and grazed twice-over treatments. The stem density and

basal cover were greater on the shallow site of the grazed twice-over treatment than those on the shallow site of the ungrazed twice-over treatment.

On the silty site of the nongrazed treatment, Hood's phlox was present during 31.6% and 50.0% of the years that density and basal cover data were collected with a mean 0.31 stems/m^2 density and a mean 0.07% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was not present where density data were collected and was present during 16.7% of the years basal cover data were collected with a mean 0.08% basal cover. During the later period (1998-2012), Hood's phlox was present during 42.9% and 60.0% of the years with a mean 0.41 stems/m^2 density and a mean 0.03% basal cover, respectively. The percent present and stem density increased and basal cover decreased on the silty site of the nongrazed treatment over time (tables 7, 8, and 9).

On the silty site of the ungrazed seasonlong treatment, Hood's phlox was present during 85.0% and 84.6% of the years that density and basal cover data were collected with a mean 2.01 stems/m^2 density and a mean 0.24% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 40.0% and 50.0% of the years with a mean 0.24 stems/m^2 density and a mean 0.09% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years with a mean 2.78 stems/m^2 density and a mean 0.27% basal cover, respectively. The percent present, stem density, and basal cover all increased 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, Hood's phlox was present during 80.0% and 73.1% of the years that density and basal cover data were collected, with a mean 6.49 stems/m^2 density and a mean 0.56% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 20.0% and 33.3% of the years, with a mean 0.02 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years, with a mean 9.26 stems/m^2 density and a mean 0.80% basal cover, respectively. The percent present, stem density, and basal cover all increased on the silty site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The stem density and basal cover were 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, Hood's phlox was present during 36.4% and 27.6% of the years that density and basal cover data were collected with a mean 0.06 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 42.9% and 33.3% of the years with a mean 0.10 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 33.3% and 20.0% of the years with a mean 0.05 stems/m^2 density and a mean 0.002% 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, Hood's phlox was present during 81.8% and 83.3% of the years that density and basal cover data were collected with a mean 1.06 stems/m^2 density and a mean 0.15% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hood's phlox was present during 42.9% and 70.0% of the years with a mean 0.20 stems/m^2 density and a mean 0.09% basal cover, respectively. During the later period (1998-2012), Hood's phlox was present during 100.0% and 100.0% of the years with a mean 1.56 stems/m^2 density and a mean 0.17% basal cover, respectively. The percent present, stem density, and basal cover all increased 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 on the sandy, shallow, and silty ecological sites were greater on the grazed management than those on the ungrazed management of both the seasonlong and twice-over treatments. The stem density and basal cover were greater on the shallow site than those on the sandy and silty sites on the nongrazed and ungrazed and grazed twice-over treatments. The stem density and basal cover were greater on the silty site than those on the sandy and shallow sites on the ungrazed and grazed seasonlong treatment. The greatest stem density and basal cover on the sandy sites was on the grazed twice-over and nongrazed treatments. The greatest stem density and basal cover on the shallow sites was the grazed twice-over and seasonlong treatments. The greatest stem

density and basal cover on the silty sites was on the grazed and ungrazed seasonlong treatment.

Hood's phlox was not present during 1988 on the sandy sites of any of the management treatments, was not present during 1988 on the nongrazed treatment on any of the ecological sites, and was not present during 1988 on the shallow site of the ungrazed seasonlong treatment. Hood's phlox was present during 1988 on the shallow and silty sites of the ungrazed and grazed twice-over treatments and on the silty site of the ungrazed seasonlong treatment.

Discussion

Hood's phlox, *Phlox hoodii*, is a late succession early cool season perennial forb of the phlox family that is commonly present on healthy mixed grass prairie plant communities. Hood's phlox can grow on sandy, shallow, silty, and clayey ecological sites. It appears to grows best on the shallow sites. Early spring aerial growth consists of dense tufts of numerous branching stems that form moss like mats arising from a woody caudex with a coarse deep woody taproot that has short lateral roots. Solitary showy flowers are terminal on stem branch tips. The mean first flower date is 24 May (1955-1962 study) with a five week flower period from early May to early June (1969-1971 study), however, late flowers can appear during early June to early July (1984-1985 study). Many of the stems did not reach the flower stage, 44.5% of the Hood's phlox stems remained vegetative. Stems grow near the ground and do not stand upright. Mean stem height was 4.6 cm (1.8 in) (1955-1962 study) and 4.7 cm (1.9 in) (1984-1985 study) during June. Mean stem weight was 0.37 g (1984-1985 study). Hood's phlox was present on the sandy site during 43.9% and 43.3% of the years density and basal cover data were collected with a mean 0.42 stems/m^2 density and a mean 0.05% basal cover. Hood's phlox was present on the silty site during 63.0% and 63.7% of the years density and basal cover data were collected with a mean 1.98 stems/m^2 density and a mean 0.21% basal cover. Hood's phlox was present on the shallow site during 77.3% and 78.8% of the years density and basal cover data were collected with a mean 2.66 stems/m^2 density and a mean 0.28% basal cover. Stem density and basal cover were greatest on the shallow sites.

The woody caudex and coarse taproot help Hood's phlox to persist during the conditions of the mixed grass prairie.

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Table 1. First flower and flower period of Phlox hoodii, Hood's phlox.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest	28					
Mean		24				
Flower Period						
1969-1971		XX XX	X			

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

Table 2. Autecology of Phlox hoodii, Hood's phlox, 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	3.0	6.0	4.6	42.2	93.3	100.0			

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Phlox hoodii, Hood's phlox, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	57.6	35.4	40.8	47.2	28.0	24.7
Bud	21.2	5.1	2.8			
Anth		0.6				
Seed Dev	18.2	22.9	4.2	1.6	1.1	
Seed Shed	3.0	8.0	12.7			
Mat		28.0	39.4	51.2	71.0	75.3
Mean Height (cm)						
Veg	4.8	3.8	3.5	4.0	3.8	3.8
Bud	4.7	5.1	5.4			
Anth		4.9				
Seed Dev	4.2	4.9	9.1	5.0	6.1	
Seed Shed	4.7	5.5	8.0			
Mat		6.1	4.6	4.7	5.3	5.3
% Dryness						
Veg	11.6	51.9	88.1	94.3	91.9	86.5
Bud	9.9	14.5	6.8			
Anth		2.0				
Seed Dev	39.8	61.2	29.5	50.0	50.0	
Seed Shed	25.0	46.4	63.5			
Mat		73.3	75.5	95.0	96.7	98.2
Mean Weight (g)	0.67	0.44	0.39	0.57	0.48	0.46

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 Phlox hoodii, Hood's phlox, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	73.9	33.6	34.6	48.2	45.7	47.6
Bud	17.4	4.0	1.3			
Anth	1.4					
Seed Dev	7.2	16.8	15.7		2.9	
Seed Shed		8.1	5.0	1.4	0.7	
Mat		37.6	43.4	50.4	50.7	52.4
Mean Height (cm)						
Veg	3.7	3.2	2.5	3.5	3.1	3.3
Bud	3.9	3.5	2.0			
Anth	3.4					
Seed Dev	4.4	3.5	3.2		3.1	
Seed Shed		3.0	2.9	2.8	3.0	
Mat		4.0	3.0	3.1	3.7	4.1
% Dryness						
Veg	14.4	54.0	87.0	91.7	95.9	95.9
Bud	17.2	33.3	2.0			
Anth	2.0					
Seed Dev	30.0	17.8	31.3		50.0	
Seed Shed		47.9	50.0	50.0	50.0	
Mat		73.3	86.1	95.4	96.7	97.4
Mean Weight (g)	0.43	0.19	0.34	0.39	0.55	0.31

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 Phlox hoodii, Hood's phlox, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	76.9	44.4	51.2	46.9	41.3	40.5
Bud	13.8	15.0	2.9	0.9		
Anth	4.6		1.2			
Seed Dev	4.6	11.9	6.5	7.1	2.7	
Seed Shed		1.9	4.1	45.1	1.3	
Mat		26.9	34.1		54.7	59.5
Mean Height (cm)						
Veg	4.4	4.2	3.9	4.3	3.7	4.2
Bud	5.3	4.6	4.6	2.4		
Anth	7.0		4.3			
Seed Dev	4.7	4.5	4.4	8.3	4.1	
Seed Shed		5.1	3.0	4.0	3.5	
Mat		5.4	4.0		5.1	5.1
% Dryness						
Veg	10.5	40.2	84.8	86.3	97.9	96.7
Bud	20.1	14.5	25.4	25.0		
Anth	1.3		6.8			
Seed Dev	25.0	29.0	27.8	65.6	25.0	
Seed Shed		9.7	46.4	90.8	50.0	
Mat		62.5	75.7		92.4	97.2
Mean Weight (g)	0.33	-	0.34	0.48	0.20	-

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 Phlox hoodii, Hood's phlox, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	71.1	43.1	7.7	40.5	46.0	40.3
Bud	11.1	5.2	1.5	1.3		
Anth						
Seed Dev	17.8	14.7	12.3	6.3	2.3	
Seed Shed		6.9	4.6	50.6		
Mat		30.2	73.8	1.3	51.7	59.7
Mean Height (cm)						
Veg	3.7	3.4	4.1	4.1	4.3	3.8
Bud	4.0	5.5	4.1	4.8		
Anth						
Seed Dev	5.0	5.9	4.1	8.7	5.1	
Seed Shed		4.6	3.9	4.3		
Mat		4.7	4.5	3.1	4.3	4.6
% Dryness						
Veg	8.4	31.3	2.0	89.8	92.0	95.7
Bud	6.2	9.4	2.0	25.0		
Anth						
Seed Dev	15.6	28.2	31.3	25.0	37.5	
Seed Shed		38.4	33.3	93.8		
Mat		55.6	82.7	98.0	96.2	98.9
Mean Weight (g)	0.19	0.08	0.32	0.33	0.22	0.50

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

Table 7. Autecology of Phlox hoodii, Hood's phlox, 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	1.48	1.61	1.89
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	3.78	7.61
1999-2003	0.00	0.00	1.01	0.53	4.49
2004-2009	4.27	0.00	0.00	0.51	7.60
2010-2012	2.90	0.00	0.00	0.76	5.10
Shallow					
1983-1987	2.99	0.00	16.25	11.55	19.31
1988-1992	0.00	0.00	1.67	0.31	0.50
1993-1998	1.51	0.00	44.35	6.85	26.88
1999-2003	2.23	2.07	25.92	3.26	22.62
2004-2009	13.42	8.81	19.87	4.45	28.79
2010-2012	3.25	6.05	14.16	1.54	12.53
Silty					
1983-1987	0.00	2.77	0.55	0.73	1.74
1988-1992	0.00	0.44	0.00	0.17	0.00
1993-1998	0.00	5.10	12.23	0.00	12.39
1999-2003	0.00	4.19	19.84	0.00	8.79
2004-2009	2.87	12.05	18.24	0.41	8.84
2010-2012	3.46	10.08	5.36	0.55	5.35

Table 8. Autecology of Phlox hoodii, Hood's phlox, 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	0.29	0.39	1.06
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.15	0.00	0.81	0.29	1.40
1999-2003	0.13	0.00	0.42	0.28	1.05
2004-2009	1.32	0.00	0.00	0.33	1.10
2010-2012	0.96	0.00	0.00	0.21	0.38
Shallow					
1983-1987	0.00	0.00	2.21	3.91	5.68
1988-1992	0.00	0.00	1.88	0.70	1.35
1993-1998	1.61	0.00	4.22	2.07	6.08
1999-2003	0.89	0.61	3.29	0.78	5.14
2004-2009	0.94	2.22	3.14	1.05	7.42
2010-2012	0.34	0.89	1.17	0.33	1.79
Silty					
1983-1987	3.39	0.99	0.00	0.41	0.80
1988-1992	0.00	0.89	0.68	0.00	0.16
1993-1998	1.00	2.04	3.39	0.06	1.42
1999-2003	0.11	1.90	4.82	0.04	1.14
2004-2009	0.36	2.34	7.15	0.01	1.44
2010-2012	0.49	0.95	0.95	0.00	0.45

Table 9. Autecology of Phlox hoodii, Hood's phlox, 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	0.01	0.02	0.03
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.04	0.07	0.27
1999-2003	0.00	0.00	0.00	0.01	0.15
2004-2009	0.13	0.00	0.00	0.01	0.23
2010-2012	0.06	0.00	0.00	0.02	0.11
Shallow					
1983-1987	0.06	0.00	0.28	0.37	0.58
1988-1992	0.00	0.00	0.01	0.01	0.01
1993-1998	0.02	0.00	0.52	0.25	0.89
1999-2003	0.07	0.03	0.47	0.11	0.91
2004-2009	0.36	0.20	0.47	0.09	0.99
2010-2012	0.13	0.12	0.28	0.03	0.28
Silty					
1983-1987	0.00	0.11	0.01	0.02	0.05
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.13	0.44	0.00	0.26
1999-2003	0.00	0.23	1.14	0.00	0.21
2004-2009	0.07	0.38	1.08	0.01	0.12
2010-2012	0.05	0.11	0.12	0.01	0.05

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