Autecology of Narrowleaved Puccoon on the Northern Mixed Grass Prairie

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The autecology of Narrowleaved puccoon, *Lithospermum incisum*, 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).

Narrowleaved puccoon, *Lithospermum incisum* Lehm., is a member of the borage family, Boraginaceae, syn.: *Lithosperumum linearifolium* Goldie, and is a native, perennial, cool season, dicot, herb. The first North Dakota record is Waldron 1904. Annual aerial growth consists of an early set of basal leaves followed by one to several erect stems unbranched at lower and widely branched and spreading upper, increasing with age 6-35 cm (2.4-13.8 in) tall arising from a persistent woody crown (caudex). Stem (cauline) leaves are alternate, narrow linear or lanceolate, 2-5 cm (0.8-2.0 in) long, 4-10 mm wide, with margins sometimes rolled backward. Stems and leaves are densely covered with course flattened hairs. The root system consists of a main slender to stout woody taproot that develops from the woody crown and can descend 2.4-3.0 m (8-10 ft) in loose soil. Small mostly unbranched lateral roots extend a short distance outward along the entire lenght of the taproot. This root system can absorb water throughout the entire depth. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown and under some severe conditions regrowth shoots can develop from segments of the taproot. Flowers are trumpet shaped arising from axils at terminal ends of main stem and branches, continuing to develop additional flowers as branches increase. Flowers have lemon yellow to orange yellow corolla of 5 petals with fringed lobes 2.5 cm (1 in) across appearing during late May to late June. Most flowers do not produce seed; only a few fertile flowers produce four hard oblong nutlets (stone seed, the origins of genus name) , each with a hard white seed. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial stems activates regrowth shoots from the crown and sometimes from the taproot. This summary information on growth development and regeneration of narrowleaved puccoon was based on works of Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Narrowleaved puccoon 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 Narrowleaved puccoon was determined by recording daily observations of plants at anthesis on several prairie habitat type collection locations distributed throughout 4,569 square miles of southwestern North Dakota. The daily observed flowering plant data collected during the growing seasons of 1969 to 1971 from April to August were reported as flower sample periods with 7 to 8 day duration in Zaczkowski 1972.

The 1983-2012 Study

A long-term study on change in abundance of Narrowleaved puccoon 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 Narrowleaved puccoon 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

Narrowleaved puccoon resumes annual aerial growth with early set of basal leaves, shortly afterwards a few erect stems widely branched and spreading above arises from a persistent woody caudex. A main woody taproot arising from the caudex can descend to 2.4-3.0 m (8-10 ft) in loose soil. Along the entire length of the taproot, numerous unbranched lateral roots extend a short distance. The entire root system is absorbent. Trumpet shaped flowers with lemon yellow to orange yellow corolla of 5 fringed petals arise from axils at terminal ends of main stems and branches. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 19 May, the mean first flowers occurred on 23 May, with a 5 week flower period extending from late May to the end of June (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 11.7 cm (4.6 in) with an annual variance in height from 7.0 cm (2.8 in) to 15.0 cm (5.9 in) was reached during June (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 6 cm (2.4 in) to 35 cm (13.8 in) tall. The mature stem heights measured during the 1955-1962 study were within normal stem heights for the Northern Plains.

Plant species composition in rangeland ecosystems is variable during a growing season and

dynamic among growing seasons. Patterns in the changes of individual plant species abundance was followed for 30 growing seasons during the 1983-2012 study on the sandy, shallow, and silty ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 3, 4, and 5).

On the sandy site of the nongrazed treatment, Narrowleaved puccoon was present during 27.8% and 4.0% of the years that density and basal cover data were collected with a mean 0.18 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 35.7% and 6.7% of the years with a mean 0.23 stems/m^2 density and a mean 0.003% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period that indicated low abundance.

On the sandy site of the ungrazed seasonlong treatment, Narrowleaved puccoon was present during 21.1% and 4.0% of the years that density and basal cover data were collected with a mean 0.11 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 26.7% and 6.7% of the years with a mean 0.13 stems/m^2 density and a mean 0.003% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period that indicated low abundance.

On the sandy site of the grazed seasonlong treatment, Narrowleaved puccoon was present during 21.1% and 8.0% of the years that density and basal cover data were collected with a mean 0.27 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the sandy site of the grazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 26.7% and 13.3% of the years with a mean 0.35 stems/m^2 density and a mean 0.01% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period. The percent present were nearly similar on the ungrazed and grazed seasonlong treatments. The 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, Narrowleaved puccoon was present during 59.1% and 10.3% of the years that density and basal cover data were collected with a mean 0.65 stems/m^2 density and a mean 0.005% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present where basal cover data were collected and was present during 16.7% of the years with a mean 0.07 stems/m^2 density. During the later period (1998-2012), Narrowleaved puccoon was present during 86.7% and 20.0% of the years with a mean 0.88 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present for density data and stem density increased greatly on the sandy site of the ungrazed twice-over treatment over time (tables 3, 4, and 5). Narrowleaved puccoon was not present with basal cover data during the early period and all observations were made during the later period.

On the sandy site of the grazed twice-over treatment, Narrowleaved puccoon was present during 71.4% and 31.0% of the years that density and basal cover data were collected with a mean 0.67 stems/m^2 density and a mean 0.025% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was present during 16.7% and 11.1% of the years with a mean 0.20 stems/m^2 density and a mean 0.10% basal cover, respectively. During the later period (1998-2012), Narrowleaved puccoon was present during 93.3% and 53.3% of the years with a mean 0.85 stems/m^2 density and a mean 0.04% basal cover, respectively. The percent present for density data, percent present for basal cover data, and stem density increased and basal cover decreased on the sandy site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present for density data, percent present for basal cover data and basal cover were slightly greater on the sandy site of the grazed twice-over treatment than those on the sandy site of the ungrazed treatment and stem density was similar on the sandy site of the ungrazed and grazed twice-over treatment.

On the shallow site of the nongrazed treatment, Narrowleaved puccoon was not present where basal cover data were collected and was present during 10.5% of the years that density data were collected with a mean 0.10 stems/m^2 density during the total 30 year period. During the early

period (1983-1992), Narrowleaved puccoon was not present on the shallow site of the nongrazed treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 14.3% of the years with a mean 0.13 stems/m^2 density. Narrowleaved puccoon was not present where basal cover data were collected and was not present where density data were collected during the early period and all density observations were made during the later period that indicated very low abundance.

On the shallow site of the ungrazed seasonlong treatment, Narrowleaved puccoon was present during 20.0% and 7.7% of the years that density and basal cover data were collected with a mean 0.12 stems/m^2 density and a mean 0.004% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 26.7% and 13.3% of the years with a mean 0.20 stems/m^2 density and a mean 0.007% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period that indicated low abundance.

On the shallow site of the grazed seasonlong treatment, Narrowleaved puccoon was present during 25.0% and 3.9% of the years that density and basal cover data were collected with a mean 0.15 stems/m^2 density and a mean 0.004% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the shallow site of the grazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 33.3% and 6.7% of the years with a mean 0.20 stems/m^2 density and a mean 0.007% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period that indicated low abundance. The percent present, stem density, and basal cover were fairly similar on the shallow site of the ungrazed and grazed seasonlong treatments.

On the shallow site of the ungrazed twice-over treatment, Narrowleaved puccoon was present during 59.1% and 10.3% of the years that density and basal cover data were collected with a mean 0.68 stems/m^2 density and a mean 0.007% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the shallow site of the ungrazed twice-over treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 86.7% and 20.0% of the years with a mean 1.00 stems/m^2 density and a mean 0.013% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period.

On the shallow site of the grazed twice-over treatment, Narrowleaved puccoon was present during 45.5% and 3.3% of the years that density and basal cover data were collected with a mean 0.37 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the shallow site of the grazed twice-over treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 66.7% and 6.7% of the years with a mean 0.54 stems/m^2 density and a mean 0.003% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period. The percent present, stem density, and basal cover were all greater on the shallow site of the ungrazed twice-over treatment than those on the shallow site of the grazed twice-over treatment.

On the silty site of the nongrazed treatment, Narrowleaved puccoon was not present where basal cover data were collected and was present during 10.5% of the years that density data were collected with a mean 0.04 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Narrowleaved puccoon was not present on the silty site of the nongrazed treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 14.3% of the years with a mean 0.06 stems/m^2 density. Narrowleaved puccoon was not present where basal cover data were collected and was not present where density data were collected during the early period and all density observations were made during the later period that indicated very low abundance.

On the silty site of the ungrazed seasonlong treatment, Narrowleaved puccoon was not present where basal cover data were collected and was present during 30.0% of the years that density data were collected with a mean 0.17 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Narrowleaved puccoon was not present on the silty site of the ungrazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 40.0% of the years with a mean 0.23 stems/m^2 density. Narrowleaved puccoon was not present where basal cover data were collected and was not present where

density data were collected during the early period and all density observations were made during the later period.

On the silty site of the grazed seasonlong treatment, Narrowleaved puccoon was present during 50.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.38 stems/m^2 density and a mean 0.008% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present on the silty site of the grazed seasonlong treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 66.7% and 13.3% of the years, with a mean 0.50 stems/m^2 density and a mean 0.007% basal cover, respectively. Narrowleaved puccoon was not present during the early period and all observations were made during the later period. The percent present, 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, Narrowleaved puccoon was not present where basal cover data were collected and was present during 9.1% of the years that density data were collected with a mean 0.04 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Narrowleaved puccoon was not present on the silty site of the ungrazed twice-over treatment. During the later period (1998-2012), Narrowleaved puccoon was present during 13.3% of the years with a mean 0.053 stems/m^2 density. Narrowleaved puccoon was not present where basal cover data were collected and was not present where density data were collected during the early period and all density observations were made during the later period that indicated low abundance.

On the silty site of the grazed twice-over treatment, Narrowleaved puccoon was present during 13.6% and 3.3% of the years that density and basal cover data were collected with a mean 0.20 stems/m^2 density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved puccoon was not present where density data were collected and was present during 10.0% of the years with a mean 0.01% basal cover. During the later period (1998-2012), Narrowleaved puccoon was not present where basal cover data were collected and was present during 20.0% of the years with a mean 0.29 stems/m^2 density. Narrowleaved puccoon was not present where density data were collected during the early period and all density observations were made during the later period that indicated low abundance. Narrowleaved puccoon was not present where basal cover data were collected during the later period and all basal cover observations were made during the early period that indicated low abundance. The percent present, stem density, and basal cover were slightly larger on the silty site of the grazed twice-over treatment than those on the silty site of the ungrazed twice-over treatment.

Narrowleaved puccoon was present on the sandy site during 41.6% and 11.5% of the years with a mean 0.37 stems/m^2 density and a mean 0.008% basal cover. Narrowleaved puccoon was present on the shallow site during 32.0% and 5.0% of the years with a mean 0.28 stems/m^2 density and a mean 0.003% basal cover. Narrowleaved puccoon was present on the silty site during 22.7% and 3.0% of the years with a mean 0.17 stems/m^2 density and a mean 0.002% basal cover. The percent present, stem density and basal cover were greater on the sandy site and least on the silty site.

On the sandy site of the nongrazed treatment, Narrowleaved puccoon was present during 27.8% and 4.0% of the years with a mean 0.18 stems/m^2 density and a mean 0.002% basal cover. On the sandy site of the seasonlong treatment, Narrowleaved blazing was present during 21.1% and 6.0% of the years with a mean 0.19 stems/m^2 density and a mean 0.004% basal cover. On the sandy site of the twice-over treatment, Narrowleaved puccoon was present during 69.1% and 20.7% of the years with a mean 0.66 stems/m^2 density and a mean 0.02% basal cover. On the
sandy sites, percent present, stem density, and basal cover were greater on the twice-over treatment.

On the shallow site of the nongrazed treatment, Narrowleaved puccoon was present during 10.5% and 0.0% of the years with a mean 0.10 stems/m^2 density and a mean 0.0% basal cover. On the shallow site of the seasonlong treatment, Narrowleaved puccoon was present during 22.5% and 5.8% of the years with a mean 0.14 stems/m^2 density and a mean 0.004% basal cover. On the shallow site of the twice-over treatment, Narrowleaved puccoon was present during 52.3% and 6.8% of the years with a mean 0.53 stems/m^2 density and a mean 0.005% basal cover. On the shallow site, percent present, stem density, and basal cover were greater on the twice-over treatment.

On the silty site of the nongrazed treatment, Narrowleaved puccoon was present during 10.5% and 0.0% of the years with a mean 0.04 stems/m^2 density

and a mean 0.0% basal cover. On the silty site of the seasonlong treatment, Narrowleaved puccoon was present during 40.0% and 5.8% of the years with a mean 0.27 stems/m^2 density and a mean 0.004% basal cover. On the silty site of the twice-over treatment, Narrowleaved puccoon was present during 11.4% and 1.7% of the years with a mean 0.12 stems/m^2 density and a mean 0.002% basal cover. On the silty site, percent present, stem density, and basal cover were greater on the seasonlong treatment.

During the growing season of 1987-1992, Narrowleaved puccoon was not present on any of the ecological sites of any of the management treatments.

Discussion

Narrowleaved puccoon, *Lithospermum incisum*, is a native, late succession, perennial, cool season dicot, forb of the borage family that is commonly present on healthy mixed grass prairie plant communities. Narrowleaved puccoon can grow on sandy, shallow, and silty ecological sites. It grows better on the sandy sites and grows best on sandy sites managed with the twice-over rotation treatment. Annual aerial growth resumes with a few erect stems arising from a perennating woody caudex. A main woody taproot with numerous unbranched lateral roots arise along its entire length can descend to 2.4-3.0 m (8-10 ft) in loose soil. Lemon yellow to orange yellow trumpet shaped flowers arise from leaf axils. The mean first flowers occurred 23 May (1955-1962 study) with a 5 week flower period extending from late May to late June (1969-1971 study). The mean mature stem height of 11.7 cm (4.6 in) was reached during June (1955-1962 study). On the sandy site, Narrowleaved puccoon had the greatest abundance, and the least abundance on the silty sites. Narrowleaved puccoon on the sandy and shallow sites had the greatest abundance on the twice-over treatment and on the silty site, the greatest abundance was on the seasonlong treatment. Narrowleaved puccoon had very low abundance on the silty sites of the nongrazed and ungrazed twice-over treatments.

The perennating woody caudex, and the deep main taproot help Narrowleaved puccoon to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Lithospermum incisum, Narrowleaved puccoon.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		19				
Mean		23				
Flower Period						
1969-1971		X	XX	XX		

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

Table 2. Autecology of Lithospermum incisum, Narrowleaved puccoon, 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	7.0	15.0	11.7		88.1	100.0			

Data from Goetz 1963.

Table 3. Autecology of Lithospermum incisum, Narrow-leaved puccoon, with growing season changes in density importance value, 1983-2012.

Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.00	0.81	2.13
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	2.24	4.30
1999-2003	0.00	0.31	1.68	3.97	6.45
2004-2009	0.99	1.43	0.00	3.88	4.33
2010-2012	5.59	0.00	4.86	7.83	6.42
Shallow					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	5.95	7.58	0.00
1999-2003	0.00	0.00	1.93	3.39	1.54
2004-2009	0.00	0.31	0.00	5.71	3.43
2010-2012	2.32	5.58	3.84	20.26	4.71
Silty					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	2.96	0.00	0.00
1999-2003	0.00	0.00	2.74	1.76	0.00
2004-2009	0.42	1.10	1.72	0.00	1.01
2010-2012	0.77	4.52	2.43	0.00	2.56

Table 4. Autecology of Lithospermum incisum, Narrow-leaved puccoon, 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	0.00	0.00	0.00	0.00	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	0.24	0.15	0.57
2004-2009	0.08	0.08	0.00	0.20	0.28
2010-2012	0.00	0.00	0.00	0.00	0.49
Shallow					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.06
1999-2003	0.00	0.00	0.00	0.08	0.00
2004-2009	0.00	0.08	0.12	0.17	0.00
2010-2012	0.00	0.16	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.00	0.00	0.00	0.08
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.14	0.00	0.00
1999-2003	0.00	0.00	0.00	0.00	0.00
2004-2009	0.00	0.00	0.14	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 5. Autecology of Lithospermum incisum, Narrow-leaved puccoon, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.00	0.01	0.04
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.04	0.07
1999-2003	0.00	0.01	0.06	0.09	0.09
2004-2009	0.01	0.03	0.00	0.08	0.07
2010-2012	0.08	0.00	0.08	0.12	0.11
Shallow					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.06	0.15	0.00
1999-2003	0.00	0.00	0.02	0.07	0.03
2004-2009	0.00	0.01	0.00	0.07	0.07
2010-2012	0.06	0.07	0.05	0.20	0.08
Silty					
1983-1987	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.04	0.00	0.00
1999-2003	0.00	0.00	0.06	0.02	0.00
2004-2009	0.01	0.03	0.04	0.00	0.06
2010-2012	0.01	0.06	0.05	0.00	0.03

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