Autecology of Narrowleaved Blazing Star on the Northern Mixed Grass Prairie

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The autecology of Narrowleaved blazing star, *Liatris punctata*, 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 blazing star, *Liatris punctata* Hook., is a member of the aster (sunflower) family, Asteraceae, and is a native, long-lived (35-50 yrs) perennial, warm season, dicot, herb that is drought resistant, shade tolerant as a seedling, and intolerant of deep litter and shading at maturity. The first North Dakota record is Haigh 1898. Annual aerial growth has a single to a cluster of few erect, stiff, unbranched stems 30-60 cm (11.8-23.6 in) tall arising from a thick, solid, subterranian, woody rootstock that develops annual rings enlarging with age. Stem (cauline) leaves are alternate, simple, stiff, thick, rough, narrow linear 5-15 cm (2.0-5.9 in) long, 2-4 mm wide, overlapping, and arching upward. The extensive root system has a large fleshy carrot-shaped taproot extending 30.5 cm (12 in) beneath the woody rootstock that tapers into a long, strong, branching taproot descending to 2.1 m (7ft) in heavy clay soil and to 3.5 m (11.5 ft) or 4.9 m (16 ft) in lighter soil. Numerous fibrous lateral roots 1 to 2 mm in diameter arise from the large fleshy portion of the taproot, extend horizontally with a radial spread of 1.1 m (3.5 ft) then forming fine branches as they descend to 3 m (10 ft) depths. Small, silvery white sparsely branched rootlets develop along the full length of each lateral root. Older roots become woody and are chocolate brown. The root segments in the top 30 cm (12 in) of soil have little or no absorption. Short rhizomes extend horizontally from the woody rootstock. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the woody rootstock with increasing numbers of sprouts with age and by sprouts from the short rhizomes. Inflorescence has numerous cylindric to bell shaped sessile heads on a dense spike 10-20 cm (3.9-7.9 in) long with flowers maturing from the bottom upwards during late July to September. Flowers are perfect, corolla of ray florets are rose purple. Pollination is by butterflies, bees, and other insects. Fruits are achene 6-7 mm long with pappus of tufted feathery bristles. Aerial parts are sometimes eaten by livestock and are totally consumed by fire. Damage to aerial stems activates sprouts from the surviving subterranian rootstock and short rhizomes. This summary information on growth development and regeneration of narrowleaved blazing star was based on works of Weaver and Fitzpatrick 1934, Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Walsh 1993, Johnson and Larson 2007, Stubbendieck et al. 2011, and Wynia ND.

Procedures

The 1955-1962 Study

Narrowleaved blazing star 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 blazing star 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 blazing star 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 blazing star 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 blazing star resumes annual aerial growth with few to several erect stiff unbranched stems arising from a thick woody caudex that develops annual rings with age. The extensive root system has large fleshy taproot that tapers as it descends to 30.5 cm (12 in) deep, forms a large strong branches and descends to 2.1 m (7 ft) in clay soils and to 3.5 m (11.5 ft) or 4.9 m (16 ft) in lighter soil. Numerous fibrous lateral roots arise from the fleshy portion of the taproot spread radially out to 1.1 m (3.5 ft), develops fine branches and descends to 3 m (10 ft) deep. Small silvery white rootlets develop along the full length of each lateral root. Rhizomes extends horizontally from the woody caudex. Numerous sessile composite heads with rose purple

ray florets develop on a dense spike. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 31 July, the mean first flowers occurred on 5 August, with a long 6 week flower period from late July to early September (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 19.9 cm (7.8 in) with an annual variance in height from 17.0 cm (6.7 in) to 23.0 cm (9.1 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 30 cm to 60 cm (11.8-23.6 in) tall. The mature stem heights measured during the 1955-1962 study were shorter than the mature stem heights for the Northern Plains. The shorter heights of Narrowleaved blazing star from 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 as a result of detrimental effects from traditional management practices.

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

On the sandy site of the nongrazed treatment, Narrowleaved blazing star was present during 38.9% and 20.0% of the years that density and basal cover data were collected with a mean 0.24 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 blazing star was not present where basal cover data were collected and was present during 75.0% of the years with a mean 0.80 stems/m^2 density. During the later period (1998-2012), Narrowleaved blazing star was present during 28.6% and 26.7% of the years with a mean 0.08 stems/m^2 density and a mean 0.009% basal cover, respectively. The percent present for density data and stem density decreased on the sandy site of the nongrazed treatment over time (tables 3, 4, and 5). Narrowleaved blazing star was not present with the basal cover data 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 blazing star was present during 15.8% and 28.0% of the years that density and basal cover data were collected with a mean 0.06 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 blazing star was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Narrowleaved blazing star was present during 20.0% and 46.7% of the years with a mean 0.07 stems/m^2 density and a mean 0.014% basal cover, respectively. Narrowleaved blazing star 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 blazing star was present during 79.0% and 48.0% of the years that density and basal cover data were collected with a mean 0.39 stems/m^2 density and a mean 0.023% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 100.0% and 40.0% of the years with a mean 0.95 stems/m^2 density and a mean 0.04% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 73.3% and 53.3% of the years with a mean 0.24 stems/m^2 density and a mean 0.015% basal cover, respectively. The percent present for density data, stem density, and basal cover decreased, and percent present for basal cover data increased on the sandy site of the grazed seasonlong treatment over time (tables 3, 4, and 5). 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, Narrowleaved blazing star was present during 95.2% and 58.6% of the years that density and basal cover data were collected with a mean 0.38 stems/m^2 density and a mean 0.027% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 100.0% and 85.7% of the years with a mean 0.70 stems/m^2 density and a mean 0.055% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 93.3% and 53.3% of the years with a mean 0.25 stems/m^2 density and a mean 0.016% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the sandy site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the sandy site of the grazed twice-over treatment, Narrowleaved blazing star was present during 95.2% and 79.3% of the years that density and

basal cover data were collected with a mean 0.47 stems/m^2 density and a mean 0.034% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 100.0% and 100.0% of the years with a mean 0.55 stems/m^2 density and a mean 0.064% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 93.3% and 80.0% of the years with a mean 0.44 stems/m^2 density and a mean 0.019% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the sandy site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were fairly similar on the ungrazed and grazed twice-over treatments.

On the shallow site of the nongrazed treatment, Narrowleaved blazing star was present during 47.4% and 53.9% of the years that density and basal cover data were collected with a mean 0.75 stems/m^2 density and a mean 0.09% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was not present where density data were collected and was present during 66.7% of the years with a mean 0.13% basal cover. During the later period (1998-2012), Narrowleaved blazing star was present during 64.3% and 66.7% of the years with a mean 1.01 stems/m^2 density and a mean 0.11% basal cover, respectively. The percent present, stem density, and basal cover changed little on the shallow site of the nongrazed treatment over time (tables 3, 4, and 5).

On the shallow site of the ungrazed seasonlong treatment, Narrowleaved blazing star was present during 50.0% and 34.6% of the years that density and basal cover data were collected with a mean 0.23 stems/m^2 density and a mean 0.024% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Narrowleaved blazing star was present during 66.7% and 46.7% of the years with a mean 0.31 stems/m^2 density and a mean 0.035% basal cover, respectively. Narrowleaved blazing star 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 blazing star was present during 95.0% and 57.7% of the years that density and basal cover data were collected with a mean 0.75 stems/m^2 density and a mean 0.06% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 80.0% and 66.7% of the years with a mean 1.06 stems/m^2 density and a mean 0.15% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 100.0% and 73.3% of the years with a mean 0.65 stems/m^2 density and a mean 0.04% basal cover, respectively. The percent present for density data and percent present for basal cover data increased and stem density and basal cover decreased on the shallow site of the grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were greater on the shallow site of the grazed seasonlong treatment than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Narrowleaved blazing star was present during 95.5% and 79.3% of the years that density and basal cover data were collected with a mean 0.89 stems/m^2 density and a mean 0.06% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 85.7% and 88.9% of the years with a mean 1.23 stems/m^2 density and a mean 0.13% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 100.0% and 86.7% of the years with a mean 0.73 stems/m^2 density and a mean 0.035% basal cover, respectively. The percent present for density data increased, percent present for basal cover data remained the same, and stem density and basal cover decreased on the shallow site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the shallow site of the grazed twice-over treatment, Narrowleaved blazing star was present during 95.5% and 80.0% of the years that density and basal cover data were collected with a mean 0.94 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 85.7% and 90.0% of the years with a mean 1.21 stems/m^2 density and a mean 0.09% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 100.0% and 86.7% of the years with a mean 0.81 stems/m^2 density and a mean 0.033% basal cover, respectively. The percent present for density data increased and percent present for basal cover data, stem density and basal cover decreased on the shallow site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem

density, and basal cover were similar on the ungrazed and grazed twice-over treatments.

On the silty site of the nongrazed treatment, Narrowleaved blazing star was present during 57.9% and 23.1% of the years that density and basal cover data were collected with a mean 0.62 stems/m^2 density and a mean 0.012% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 60.0% and 16.7% of the years with a mean 0.80 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 57.1% and 33.3% of the years with a mean 0.56 stems/m^2 density and a mean 0.015% basal cover, respectively. The percent present for basal cover data increased and percent present for density data, stem density, and basal cover decreased on the silty site of the nongrazed treatment over time (tables 3, 4, and 5).

On the silty site of the ungrazed seasonlong treatment, Narrowleaved blazing star was present during 70.0% and 46.2% of the years that density and basal cover data were collected with a mean 0.37 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 60.0% and 66.7% of the years with a mean 0.68 stems/m^2 density and a mean 0.032% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 73.3% and 40.0% of the years with a mean 0.27 stems/m^2 density and a mean 0.015% basal cover, respectively. The percent present for density data increased and percent present for basal cover data, stem density, and basal cover decreased on the silty site of the ungrazed seasonlong treatment over time (tables 3, 4, and 5).

On the silty site of the grazed seasonlong treatment, Narrowleaved blazing star was present during 50.0% and 34.6% of the years that density and basal cover data were collected with a mean 0.21 stems/m^2 density and a mean 0.031% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 40.0% and 16.7% of the years with a mean 0.12 stems/m^2 density and a mean 0.028% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 53.3% and 53.3% of the years, with a mean 0.23 stems/m^2 density and a mean 0.043% 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 3, 4, and 5). The percent present for density data, percent present for basal cover data, and stem density were greater and basal cover was lower on the silty site of the ungrazed seasonlong treatment than those on the silty site of the grazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, Narrowleaved blazing star was present during 63.6% and 27.6% of the years that density and basal cover data were collected with a mean 0.21 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 blazing star was present 57.1% and 22.2% of the years with a mean 0.17 stems/m^2 density and a mean 0.006% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 66.7% and 33.3% of the years with a mean 0.22 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present, stem density and basal cover all increased on the silty site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the silty site of the grazed twice-over treatment, Narrowleaved blazing star was present during 59.1% and 40.0% of the years that density and basal cover data were collected with a mean 0.14 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Narrowleaved blazing star was present during 71.4% and 40.0% of the years with a mean 0.24 stems/m^2 density and a mean 0.019% basal cover, respectively. During the later period (1998-2012), Narrowleaved blazing star was present during 53.3% and 53.3% of the years with a mean 0.09 stems/m^2 density and a mean 0.008% basal cover, respectively. The percent present for basal cover data increased, and percent present for density data, stem density, and basal cover decreased on the silty site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were somewhat similar on the silty site of the ungrazed and grazed twice-over treatments.

On the sandy site, Narrowleaved blazing star was present during 64.8% and 46.8% of the years with a mean 0.31 stems/m^2 density and a mean 0.02% basal cover. On the shallow site, Narrowleaved blazing star was present during 76.7% and 61.1% of the years with a mean 0.71 stems/m^2 density and a mean 0.06% basal cover. On the silty site, Narrowleaved blazing star was present during 60.1% and 34.3% of the years with a mean 0.31 stems/m^2

density and a mean 0.02% basal cover. The percent present, stem density and basal cover were all greater on the shallow site.

Narrowleaved blazing star was present on the nongrazed treatment during 48.1% and 32.3% of the years with a mean 0.54 stems/m^2 density and a mean 0.04% basal cover. Narrowleaved blazing was present on the seasonlong treatment during 60.0% and 41.5% of the years with a mean 0.33 stems/m^2 density and a mean 0.03% basal cover. Narrowleaved blazing star was present on the twice-over treatment during 84.0% and 60.8% of the years with a mean 0.50 stems/m^2 density and a mean 0.03% basal cover. The percent present for density data and percent present for basal cover data were greater on the twice-over treatment. Stem density and basal cover were slightly greater on the nongrazed treatment.

During the drought growing season of 1988; Narrowleaved blazing star was present on the nongrazed treatment 4 times out of a possible 6 for an index of 66.7%; Narrowleaved blazing star was present on the seasonlong treatment 8 times out of a possible 12 for an index of 66.7%; and Narrowleaved blazing star was present on the twice-over treatment 10 times out of a possible 12 for an index of 83.3%. Narrowleaved blazing star appears to have good drought tolerance mechanisms.

Discussion

Narrowleaved blazing star, *Liatris punctata*, is a native, late succession, long-lived perennial, warm season dicot, forb of the aster family that is commonly present on healthy mixed grass prairie plant communities. Narrowleaved blazing star can grow on sandy, shallow, and silty ecological sites. It grows better on the shallow site. Annual aerial growth resumes with usually several stiff unbranched stems arising from a perennating woody caudex. The caudex develops annual rings and enlarges as it ages. The remarkable root system has a large fleshy taproot that tapers and branches as it descends to 2.1 m (7 ft) or 4.9 m (16 ft) deep. Numerous fibrous lateral roots spread horizontally before descending to 3 m (10 ft). Older roots become woody and turn chocolate brown. A rhizome system extends outward from the woody caudex. Rose purple flowers develop on a dense spike 10-20 cm (3.4-7.9 in) long. The mean first flower date is 5 August (1955-1962 study) with a 6 week flower period from late July to early September (1969-1971 study). The mean mature stem height of 19.9 cm (7.8 in) is reached during August (1955-1962 study).

Narrowleaved blazing star had good abundance on each ecological site on all three management treatments and has good drought tolerance mechanisms.

The enlarging woody caudex, rhizome system, and remarkable root system help Narrowleaved blazing star to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Liatris punctata, Blazing star.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest				31		
Mean					5	
Flower Period						
1969-1971				X	XX XX X	

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

Table 2. Autecology of Liatris punctata, Blazing star, 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	17.0	23.0	19.9		30.0	57.8	95.2	100.0	

Data from Goetz 1963.

Table 3. Autecology of Liatris punctata, Blazing star or Dotted gayfeather, 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	6.70	0.00	2.08	3.48	4.29
1988-1992	6.13	0.00	7.92	7.36	2.56
1993-1998	0.00	0.00	3.02	2.70	2.07
1999-2003	0.00	0.26	1.03	1.65	3.03
2004-2009	0.33	0.22	0.66	1.26	3.28
2010-2012	0.83	0.78	2.26	0.82	0.62
Shallow					
1983-1987	0.00	0.00	8.00	5.88	5.61
1988-1992	0.00	0.00	12.08	10.49	11.29
1993-1998	0.00	0.00	6.88	3.43	3.28
1999-2003	0.00	1.01	6.87	2.39	4.21
2004-2009	11.16	2.51	2.84	4.90	3.94
2010-2012	8.41	4.63	3.56	4.78	5.93
Silty					
1983-1987	1.46	3.23	0.00	0.29	0.13
1988-1992	6.31	3.56	2.45	3.77	5.23
1993-1998	3.77	0.00	0.00	0.00	2.27
1999-2003	1.33	1.63	0.45	2.87	0.15
2004-2009	1.12	0.54	1.69	1.04	0.74
2010-2012	9.47	2.77	0.18	0.96	1.10

Table 4. Autecology of Liatris punctata, Blazing star or Dotted gayfeather, with growing season changes in basal cover importance value, 1983-2012.

Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.00	0.28	0.30
1988-1992	0.00	0.00	0.69	0.71	1.35
1993-1998	0.05	0.00	0.16	0.18	0.06
1999-2003	0.00	0.03	0.15	0.36	0.18
2004-2009	0.20	0.26	0.08	0.12	0.18
2010-2012	0.08	0.06	0.10	0.00	0.07
Shallow					
1983-1987	0.46	0.00	1.60	0.57	0.43
1988-1992	1.40	0.00	1.57	1.66	1.12
1993-1998	0.00	0.12	0.04	0.05	0.17
1999-2003	0.15	0.09	0.41	0.31	0.30
2004-2009	1.17	0.42	0.34	0.44	0.33
2010-2012	1.85	0.30	0.08	0.10	0.09
Silty					
1983-1987	0.00	0.33	0.00	0.00	0.07
1988-1992	0.22	0.33	0.30	0.09	0.23
1993-1998	0.00	0.17	0.00	0.13	0.00
1999-2003	0.20	0.23	0.08	0.15	0.07
2004-2009	0.11	0.05	0.68	0.04	0.08
2010-2012	0.00	0.00	0.09	0.00	0.00

Table 5. Autecology of Liatris punctata, Blazing star or Dotted gayfeather, with growing season changes in density, 1983-2012.

Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.04	0.00	0.03	0.05	0.07
1988-1992	0.09	0.00	0.12	0.09	0.04
1993-1998	0.00	0.00	0.05	0.05	0.05
1999-2003	0.00	0.01	0.01	0.03	0.06
2004-2009	0.01	0.00	0.01	0.02	0.04
2010-2012	0.02	0.02	0.04	0.02	0.01
Shallow					
1983-1987	0.00	0.00	0.11	0.13	0.12
1988-1992	0.00	0.00	0.10	0.12	0.13
1993-1998	0.00	0.00	0.08	0.07	0.04
1999-2003	0.00	0.01	0.11	0.06	0.10
2004-2009	0.16	0.04	0.04	0.09	0.07
2010-2012	0.15	0.07	0.04	0.06	0.08
Silty					
1983-1987	0.02	0.11	0.00	0.01	0.01
1988-1992	0.10	0.06	0.02	0.03	0.04
1993-1998	0.18	0.00	0.00	0.00	0.04
1999-2003	0.08	0.04	0.01	0.04	0.00
2004-2009	0.01	0.01	0.05	0.02	0.01
2010-2012	0.07	0.04	0.00	0.01	0.01

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