Autecology of Scarlet Gaura on the Northern Mixed Grass Prairie

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The autecology of Scarlet gaura, *Gaura coccinea*, 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).

Scarlet gaura, *Gaura coccinea* Nutt. ex Pursh, is a member of the evening primrose family, Onagraceae, syn.: *Oenothera suffrutescens* (Ser.) W.L. Wagner & Hoch, and is a native, perennial, dicot, herb. The first North Dakota record is Bergman 1910. Annual aerial growth has a single to several erect or ascending, branched stems 20-30 cm (7.9-11.8 in) tall arising from a persistent woody crown (caudex). Stem leaves are alternate, linear to narrowly elliptic, 1-3 cm (0.4-1.2 in) long, 1-7 mm wide, entire, sessile, crowded on the stem. Stems and leaves are densely covered with gray hairs. The root system has a deep, thick taproot with fibrous lateral roots. An extensive, spreading horizontal rhizome system develops from the woody crown that can form large colonies. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown and by sprouts from the rhizome system. Inflorescence has numerous sessile flowers on a spike. Flowers have four long, stiff sepals that hang towards the stem and has four white to scarlet spoon shaped petals, 1 cm (0.4 in) wide that open in the evening of the first day and close before evening the next day that appear during late May to mid July. Pollination is by nocturnal moths. Fruit is a woody cylindric capsule about 5 mm long. 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 the rhizome system. This summary information on growth development and regeneration of Scarlet gaura was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Stubbendieck et al. 2003, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Scarlet gaura 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 Scarlet gaura 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 Scarlet gaura 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 Scarlet gaura 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

Scarlet gaura resumes annual aerial growth with a single to several branched stems arising from a persistent woody caudex. Stems and leaves are covered with dense gray hairs. A deep thick taproot descends from the caudex. Numerous fibrous lateral roots arise from the taproot. An extensive subterranean horizontal rhizome system spreads from the caudex forming large colonies. Numerous sessile flowers with four white to scarlet spoon shaped petals develop on a spike open in the evening on day one and close by evening on day two. On the fall grazed pastures of the 1955-1962 study, the mean first flowers occurred on 10 June, and the long 7 week flower period extends from the last week of May through June to the middle of July (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 18.0 cm (7.1 in) with an annual variance in height from 12.0 cm (4.7 in) to 22.0 cm (8.7 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20 cm to 30 cm (7.9-11.8 in) tall. The mature stem heights measured during the 1955-1962 study were within the short end or shorter than normal stem height 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 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 3, 4, and 5).

On the sandy site of the nongrazed treatment, Scarlet gaura was present during 66.7% and 48.0% of the years that density and basal cover data were collected, with a mean 2.37 stems/m^2 density and a mean 0.074% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was not present where density data were collected and was present during 40.0% of the years with a mean 0.13% basal cover. During the later period (1998-2012), Scarlet gaura was present during 85.7% and 60.0% of the years with a mean 3.04 stems/m^2 density and a mean 0.077% basal cover, respectively. The percent present for basal cover data increased and basal cover decreased (tables 3, 4, and 5). Scarlet gaura was not present with the density data during the early period and all density data observations were made during the later period.

On the sandy site of the ungrazed seasonlong treatment, Scarlet gaura was present during 52.6% and 24.0% of the years that density and basal cover data were collected with a mean 0.66 stems/m^2 density and a mean 0.013% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Scarlet gaura was present during 66.7% and 40.0% of the years with a mean 0.83 stems/m^2 density and a mean 0.022% basal cover, respectively. Scarlet gaura was not present during the early period and all observations were made during the later period.

On the sandy site of the grazed seasonlong treatment, Scarlet gaura was present during 63.2% and 28.0% of the years that density and basal cover data were collected with a mean 0.91 stems/m^2 density and a mean 0.026% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was not present where density data were collected and was present during 40.0% of the years with a mean 0.012% basal cover. During the later period (1998-2012), Scarlet gaura was present during 80.0% and 33.3% of the years with a mean 1.15 stems/m^2 density and a mean 0.039% basal cover, respectively. The percent present for basal cover data decreased and basal cover increased slightly on the sandy site of the grazed seasonlong treatment (tables 3, 4, and 5). Scarlet gaura was not present with the density data during the early period and all density data observations were made during the later period. The percent present for density data and percent present for basal cover data were similar on the sandy site of the ungrazed and grazed seasonlong treatment. 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, Scarlet gaura was present during 90.5% and 51.7% of the years that density and basal cover data were collected with a mean 1.04 stems/m^2 density and a mean 0.021% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 66.7% and 50.0% of the years with a mean 0.60 stems/m^2 density and a mean 0.013% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 100.0% and 60.0% of the years with a mean 1.22 stems/m^2 density and a mean 0.027% 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 3, 4, and 5).

On the sandy site of the grazed twice-over treatment, Scarlet gaura was present during 100.0% and 44.8% of the years that density and basal cover data were collected with a mean 1.27 stems/m^2 density and a mean 0.013% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 100.0% and 22.2% of the years with a mean 0.58 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 100.0% and 60.0% of the years with a mean 1.54 stems/m^2 density and a mean 0.012% basal cover, respectively. The percent present for density data remained the same, percent present for basal cover data and stem density increased and basal cover decreased slightly 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, stem density and basal cover were similar on the sandy site of the ungrazed and grazed twice-over treatments.

On the shallow site of the nongrazed treatment, Scarlet gaura was present during 79.0% and 34.6% of the years that density and basal cover data were collected with a mean 1.40 stems/m^2 density and a mean 0.026% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 40.0% and 16.7% of the years with a mean 0.96 stems/m^2 density and a mean 0.008% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 92.9% and 53.3% of

the years with a mean 1.90 stems/m^2 density and a mean 0.041% basal cover, respectively. The percent present, stem density, and basal cover all increased on the shallow site of the nongrazed treatment over time (tables 3, 4, and 5).

On the shallow site of the ungrazed seasonlong treatment, Scarlet gaura was present during 35.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.18 stems/m^2 density and a mean 0.006% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Scarlet gaura was present during 46.7% and 20.0% of the years with a mean 0.23 stems/m^2 density and a mean 0.011% basal cover, respectively. Scarlet gaura was not present during the early period and all observations were made during the later period.

On the shallow site of the grazed seasonlong treatment, Scarlet gaura was present during 75.0% and 46.2% of the years that density and basal cover data were collected with a mean 1.76 stems/m^2 density and a mean 0.08% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 60.0% and 50.0% of the years with a mean 1.14 stems/m^2 density and a mean 0.22% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 80.0% and 53.3% of the years with a mean 1.97 stems/m^2 density and a mean 0.051% basal cover, respectively. The percent present and stem density increased 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, Scarlet gaura was present during 95.5% and 58.6% of the years that density and basal cover data were collected with a mean 1.96 stems/m^2 density and a mean 0.034% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 85.7% and 44.4% of the years with a mean 2.44 stems/m^2 density and a mean 0.026% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 100.0% and 66.7% of the years with a mean 1.89 stems/m^2 density and a mean 0.037% basal cover, respectively. The percent present and basal cover increased and stem density 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, Scarlet gaura was present during 95.5% and 53.3% of the years that density and basal cover data were collected with a mean 1.31 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 85.7% and 60.0% of the years with a mean 1.09 stems/m^2 density and a mean 0.052% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 100.0% and 60.0% of the years with a mean 1.41 stems/m^2 density and a mean 0.021% basal cover, respectively. The percent present for the density data and stem density increased, percent present for basal cover data remained the same, 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 shallow site of the ungrazed and grazed twice-over treatments

On the silty site of the nongrazed treatment, Scarlet gaura was present during 84.2% and 46.2% of the years that density and basal cover data were collected with a mean 3.20 stems/m^2 density and a mean 0.06% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 40.0% and 33.3% of the years with a mean 0.40 stems/m^2 density and a mean 0.017% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 100.0% and 60.0% of the years with a mean 4.34 stems/m^2 density and a mean 0.07% basal cover, respectively. The percent present, stem density, and basal cover all increased on the silty site of the nongrazed treatment over time (tables 3, 4, and 5).

On the silty site of the ungrazed seasonlong treatment, Scarlet gaura was present during 70.0% and 38.5% of the years that density and basal cover data were collected with a mean 1.44 stems/m^2 density and a mean 0.046% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 80.0% and 33.3% of the years with a mean 0.68 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 80.0% and 33.3% of the years with a mean 1.69 stems/m^2 density and a mean 0.03% basal cover, respectively. The percent present for the density data and stem density increased, percent present for the basal cover data

remained the same, 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, Scarlet gaura was present during 75.0% and 26.9% of the years that density and basal cover data were collected with a mean 1.07 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 20.0% and 33.3% of the years with a mean 1.22 stems/m^2 density and a mean 0.033% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 93.3% and 33.3% of the years, with a mean 1.02 stems/m^2 density and a mean 0.02% 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 slightly 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, stem density, and basal cover were fairly similar on the silty site of the ungrazed and grazed seasonlong treatments.

On the silty site of the ungrazed twice-over treatment, Scarlet gaura was present during 36.4% and 13.8% of the years that density and basal cover data were collected with a mean 0.07 stems/m^2 density and a mean 0.005% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was not present where basal cover data were collected and was present during 42.9% of the years with a mean 0.07 stems/m^2 density. During the later period (1998-2012), Scarlet gaura was present during 33.3% and 13.3% of the years with a mean 0.07 stems/m^2 density and a mean 0.006% basal cover, respectively. The percent present for density data and stem density decreased slightly and Scarlet gaura 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 (tables 3, 4, and 5).

On the silty site of the grazed twice-over treatment, Scarlet gaura was present during 50.0% and 26.7% of the years that density and basal cover data were collected with a mean 0.19 stems/m^2 density and a mean 0.005% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet gaura was present during 28.6% and 10.0% of the years with a mean 0.11 stems/m^2 density and a mean 0.007% basal cover, respectively. During the later period (1998-2012), Scarlet gaura was present during 60.0% 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 for density data, percent present for basal cover data and stem density increased, and basal cover remained the same on the silty 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, stem density, and basal cover were slightly greater on the silty site of the grazed twice-over treatments than those on the silty site of the ungrazed twice-over treatment.

On the sandy site, Scarlet gaura was present during 74.6% and 39.3% of the years with a mean 1.25 stems/m^2 density and a mean 0.03% basal cover. On the shallow site, Scarlet gaura was present during 76.0% and 40.0% of the years with a mean 1.32 stems/m^2 density and a mean 0.04% basal cover. On the silty site, Scarlet gaura was present during 63.1% and 30.4% of the years with a mean 1.19 stems/m^2 density and a mean 0.03% basal cover. The percent present for density data, percent present for basal cover data, stem density and basal cover were remarkably similar on the three different ecological sites.

Scarlet gaura on the sandy site of the nongrazed treatment was present during 66.7% and 48.0% of the years with a mean 2.37 stems/m^2 density and a mean 0.07% basal cover. Scarlet gaura on the sandy site of the seasonlong treatment was present during 57.9% and 26.0% of the years with a mean 0.78 stems/m^2 density and a mean 0.02% basal cover. Scarlet gaura on the sandy site of the twice-over treatment was present during 95.2% and 48.3% of the years with a mean 1.16 stems/m^2 density and a mean 0.02% basal cover. The percent present for density data and percent present for basal cover data were greater on the twice-over treatment and the stem density and basal cover were greater on the nongrazed treatment.

Scarlet gaura on the shallow site of the nongrazed treatment was present during 79.0% and 34.6% of the years with a mean 1.40 stems/m^2 density and a mean 0.03% basal cover. Scarlet gaura on the shallow site of the seasonlong treatment was present during 55.0% and 28.9% of the years with a mean 0.97 stems/m^2 density and a mean 0.04% basal cover. Scarlet gaura on the shallow site of the twice-over treatment was present during 95.5% and 56.0% of the years with a mean 1.64 stems/m^2 density and a mean 0.03% basal cover. The percent present for density data, percent present for basal cover data and stem density were greater on the twice-over treatment and

basal cover was slightly greater on the seasonlong treatment.

Scarlet gaura on the silty site of the nongrazed treatment was present during 84.2% and 46.2% of the years with a mean 3.20 stems/m^2 density and a mean 0.06% basal cover. Scarlet gaura on the silty site of the seasonlong treatment was present during 72.5% and 32.7% of the years with a mean 1.25 stems/m^2 density and a mean 0.03% basal cover. Scarlet gaura on the silty site of the twice-over treatment was present during 43.2% and 20.2% of the years with a mean 0.13 stems/m^2 density and a mean 0.005% basal cover. The percent present for density data, percent present for basal cover data, stem density, and basal cover were greater on the nongrazed treatment.

During the drought growing season of 1988; Scarlet gaura was present on the nongrazed treatment 4 times out of a possible 6 for an index of 66.7%; Scarlet gaura was present on the seasonlong treatment 7 times out of a possible 12 for an index of 58.3%; and Scarlet gaura was present on the twice-over treatment 8 times out of a possible 12 for an index of 66.7%. Scarlet gaura appears to have fairly good drought tolerance mechanisms.

Discussion

Scarlet gaura, *Gaura coccinea*, is a native, late succession, perennial, dicot, forb of the evening primrose family that is commonly present on healthy mixed grass prairie plant communities. Scarlet gaura is quite versatile and can grow with about equal abundance on sandy, shallow, and silty ecological sites. Annual aerial growth has one to several erect or ascending, branching stems that arise from a perennating caudex with a deep thick taproot that has numerous fibrous lateral roots. An extensive rhizome system extends horizontally from the caudex and can form large colonies. Numerous delicate sessile flowers develop on a spike. The mean first flower date is 10 June (1955-1962 study) with a long 7 week flower period from late May to mid July (1969-1971 study). Mean mature stem height of 18.0 cm (7.1 in) was reached during August (1955-1962 study). The percent present for density data and percent present for basal cover data were greatest on the sandy and shallow sites of the twice-over treatment and was greatest on the silty site of the nongrazed treatment. Stem density was greatest on the sandy and shallow sites of the nongrazed treatment and on the shallow site of the twice-over treatment. Basal cover was fairly similar on each ecological site of the three management treatments. Scarlet gaura demonstrated good drought tolerance during the drought growing season of 1988 on all management treatments.

The perennating woody caudex, the deep, thick taproot with numerous fibrous lateral roots, and the extensive spreading horizontal rhizome system that can form large colonies help Scarlet gaura to persist through the harsh conditions on the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Gaura coccinea, Scarlet gaura.

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

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

Table 2. Autecology of Gaura coccinea, Scarlet gaura, 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	12.0	22.0	18.0		45.5	80.6	98.6	100.0	

Data from Goetz 1963.

Table 3. Autecology of Gaura coccinea, Scarlet gaura, 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	5.33	4.41
1988-1992	0.00	0.00	0.00	3.89	4.46
1993-1998	15.89	0.00	8.63	8.01	19.86
1999-2003	27.00	1.81	10.90	10.66	15.30
2004-2009	9.23	5.36	0.76	2.82	3.68
2010-2012	1.43	4.09	3.67	2.22	2.46
Shallow					
1983-1987	8.19	0.00	10.12	14.89	7.38
1988-1992	7.64	0.00	16.01	8.03	7.52
1993-1998	9.29	0.00	25.32	9.60	11.40
1999-2003	13.23	0.72	34.04	12.52	11.59
2004-2009	4.23	2.65	2.68	4.63	2.29
2010-2012	6.92	0.81	0.76	2.87	2.39
Silty					
1983-1987	6.77	1.97	0.00	0.64	0.83
1988-1992	2.10	4.82	10.30	0.00	0.00
1993-1998	41.72	7.92	4.69	0.00	0.88
1999-2003	26.83	10.47	6.36	0.69	3.56
2004-2009	4.37	2.28	1.89	0.36	0.12
2010-2012	4.67	3.83	5.43	0.00	1.07

Table 4. Autecology of Gaura coccinea, Scarlet gaura, 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	0.50	0.00	0.29	0.12	0.09
1988-1992	1.15	0.00	0.07	0.13	0.18
1993-1998	0.07	0.00	0.00	0.26	0.04
1999-2003	1.62	0.06	0.91	0.74	0.25
2004-2009	0.43	0.47	0.17	0.06	0.06
2010-2012	0.00	0.07	0.00	0.00	0.00
Shallow					
1983-1987	0.46	0.00	0.00	0.18	0.19
1988-1992	0.00	0.00	1.89	0.43	0.63
1993-1998	0.00	0.00	0.04	0.28	0.15
1999-2003	0.93	0.05	1.06	0.81	0.37
2004-2009	0.13	0.19	0.11	0.12	0.06
2010-2012	0.07	0.00	0.00	0.03	0.00
Silty					
1983-1987	0.00	0.00	0.00	0.00	0.06
1988-1992	0.16	0.52	0.37	0.00	0.00
1993-1998	0.28	0.61	0.00	0.08	0.04
1999-2003	1.63	0.84	0.40	0.34	0.20
2004-2009	0.27	0.03	0.07	0.00	0.02
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 5. Autecology of Gaura coccinea, Scarlet gaura, 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	0.08	0.07
1988-1992	0.00	0.00	0.00	0.04	0.04
1993-1998	0.46	0.00	0.17	0.17	0.38
1999-2003	0.75	0.05	0.26	0.25	0.29
2004-2009	0.12	0.14	0.02	0.05	0.06
2010-2012	0.03	0.06	0.05	0.05	0.04
Shallow					
1983-1987	0.20	0.00	0.16	0.39	0.16
1988-1992	0.07	0.00	0.10	0.08	0.07
1993-1998	0.28	0.00	0.20	0.17	0.16
1999-2003	0.41	0.01	0.50	0.39	0.31
2004-2009	0.06	0.04	0.04	0.09	0.05
2010-2012	0.14	0.01	0.02	0.05	0.04
Silty					
1983-1987	0.12	0.05	0.00	0.01	0.02
1988-1992	0.02	0.07	0.15	0.00	0.00
1993-1998	1.40	0.24	0.07	0.00	0.01
1999-2003	0.80	0.36	0.20	0.01	0.05
2004-2009	0.08	0.05	0.04	0.01	0.00
2010-2012	0.07	0.06	0.06	0.00	0.02

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