Autecology of Scarlet Globemallow on the Northern Mixed Grass Prairie

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The autecology of Scarlet globemallow, *Sphaeralcea 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 globemallow, *Sphaeralcea coccinea* (Nutt.) Rydb., is a member of the mallow family, Malvaceae, syn.: *Malvastrum coccineum* (Nutt.) A. Gray, and is a native, long lived (35 yrs) perennial, warm-season, dicot, herb that is extremely drought tolerant and shade intolerant. The first North Dakota record is Bergman 1911. Annual aerial growth has a single to several clustered ascending to decumbent stems 10-20 cm (3.9-7.8 in) tall arising from a persistent woody crown (caudex). Leaves are alternate 2-6 cm (0.8-2.4 in) long with 3 to 5 deeply palmately irregular lobes. Stems and leaves are densely covered with star shaped (stellate) hairs causing a gray-green color. The underside of leaves are densely pubescent. The root system consists of a main stout woody taproot that develops from the crown and descends 90 cm (35.4 in) unbranched and divides into lateral roots and then can descend to 2.4-4.0 m (8-13 ft) in loose soil. One or two large lateral roots 0.1-0.3 cm (0.04-0.12 in) in diameter arise from the top 30.5 cm (12 in) of the taproot extending downward, parallel to the taproot. Small roots extend horizontally outward to 20.3 cm (8 in) mostly unbranched along the entire length of the taproot. This root system can absorb water throughout the entire depth, however, absorption in the top 61 cm (2 ft) of soil is not of great importance compared to the absorption in the lower depths. Spreading rhizomes that remain between 2.0 and 10.2 cm (0.8 and 4.0 in) below the soil surface develop from the woody crown. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown and by sprouts from the rhizomes. Inflorescence has numerous densely clustered flowers on a short terminal raceme. Flowers have 5 petals deep orange to salmon appearing during early June to September. Pollination is by insects. Fruit is a dry indehiscent schizocarp that splits into ten one seeded segments (carpels) at maturity. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial stems activates sprouts from the rhizomes. This summary information on growth development and regeneration of Scarlet globemallow was based on works of Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Tollefson 2006, Larson and Johnson 2007, St. John and Ogle 2009, and Stubbendieck et al. 2011.

Procedures

The 1955-1962 Study

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

The 1984-1985 Study

Scarlet globemallow plant growth in height was determined by measuring stems from ground level to top of stem or leaf or to the tip of the inflorescence of 59 ungrazed specimens randomly

selected on three replications of grazed sandy, shallow, silty, and clayey ecological sites biweekly during June, July, and August of the growing seasons of 1984 and 1985. Phenological growth stage of each specimen was recorded as vegetative, budding, anthesis, seed developing, seed shedding, or mature. Percentage of stem dryness of each specimen was recorded as 0, 0-2, 2-25, 25-50, 50-75, 75-98, or 100 percent dry. Mean stem weight was determined by clipping at ground level 11 specimens at typical phenological growth stages at biweekly sample dates on separate grazed areas of the sandy, shallow, silty, and clayey ecological sites. Clipped stems at each sample site were placed in separate labeled paper bags of known weight, oven dried at 62° C (144° F), and weighed in grams.

The 1983-2012 Study

A long-term study on change in abundance of Scarlet globemallow 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 globemallow 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 globemallow resumed growth in spring with one to several stems arising from a persistent woody crown with a spreading rhizome system and a stout woody taproot that descends to 90 cm (36 in), divides and can descend to 4.0 m (13 ft) with an extensive lateral root system. Numerous clusters of flowers with orange to salmon petals develop on short racemes. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 4 June, the mean first flowers occurred on 13 June, and a long nine week flower period that extended from early June to early August occurred on the 1969-1971 study (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 11.8 cm (4.6 in) with an annual variance in height from 10.0 cm (3.9 in) to 13.0 cm (5.1 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 10 cm to 20 cm (3.9-7.8 in) tall. The mean stem heights collected during the 1955-1961 study were within the normal range for the Northern Plains.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 3,377 Scarlet globemallow stems were sampled during this study with, 772 stems (22.9%) from the sandy sites, 901 stems (26.7%) from the shallow sites, 1,040 stems (30.8%) from the silty sites, and 664 stems (19.7%) from the clayey ecological sites. Scarlet globemallow can grow on sandy, shallow, silty, and clayey ecological sites. It appears to grow best on the shallow and silty sites. Mean mature stem heights were, 10.9 cm (4.3 in) on the sandy sites, 9.8 cm (3.9 in) on the shallow sites, 11.5 cm (4.5 in) on the silty sites, and 11.6 cm (4.6 in) on the clayey sites and were not significantly different. The mean mature stem heights collected during the 1984-1985 study were near or within the normal range in stem height for the Northern Plains. Mean stem weights were, 0.28 g on the sandy sites, 0.17 g on the shallow sites, 0.24 g on the silty sites, and 0.23 g on the clayey sites, and were not significantly different.

During the growing season, 82.1% of the Scarlet globemallow stems remained at the vegetative growth stage and did not produce flowers. The percentage of Scarlet globemallow stems that had passed through the anthesis phenological growth stage was 5.3% by early June, 8.3% by late June, 5.8% by early July, 5.8% by late July, and 12.9% by early August. Flowers were observed to occur during 8 weeks from early June to late July.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Patterns in the changes in individual plant species abundance was followed for 30 growing seasons during the 1983-2012 study on the sandy, shallow, and silty ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 7, 8, and 9).

On the sandy site of the nongrazed treatment, Scarlet globemallow was present during 27.8% and 4.0% of the years that density and basal cover data were collected, with a mean 0.16 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Scarlet globemallow was present during 35.7% and 6.7% of the years with a mean 0.20 stems/m^2 density and a mean 0.002% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the nongrazed treatment over time (tables 7, 8, and 9).

On the sandy site of the ungrazed seasonlong treatment, Scarlet globemallow was not present during the 30 year period.

On the sandy site of the grazed seasonlong treatment, Scarlet globemallow was present during 42.1% and 12.0% of the years that density and basal cover data were collected with a mean 0.20 stems/m^2 density and a mean 0.01% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 75.0% and 20.0% of the years with a mean 0.28 stems/m^2 density and a mean 0.17% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 33.3% and 13.3% of the years with a mean 0.17 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density and basal cover all decreased on the sandy site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the sandy site of the grazed seasonlong treatment than those on the sandy site of the ungrazed seasonlong treatment.

On the sandy site of the ungrazed twice-over treatment, Scarlet globemallow was present during 52.4% and 34.5% of the years that density and basal cover data were collected, with a mean 0.11 stems/m^2 density and a mean 0.01% basal cover during the total

30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 83.3% and 50.0% of the years with a mean 0.28 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 40.0% and 13.3% of the years with a mean 0.05 stems/m^2 density and a mean 0.001% 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 7, 8, and 9).

On the sandy site of the grazed twice-over treatment, Scarlet globemallow was present during 76.2% and 55.2% of the years that density and basal cover data were collected with a mean 0.61 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 globemallow was present during 33.3% and 55.6% of the years with a mean 0.15 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 93.3% and 46.7% of the years with a mean 0.79 stems/m^2 density and a mean 0.02% basal cover, respectively. The percent present for the density data and stem density increased and the percent present for the basal cover data and basal cover decreased on the sandy site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the sandy site of the grazed twice-over treatment than those on the sandy site of the ungrazed twice-over treatment, except during the early period, the percent present for the density data and density were greater on the sandy site of the ungrazed twice-over treatment than those on the sandy site of the grazed twice-over treatment.

During the 30 year period, Scarlet globemallow stem density and basal cover were low on the sandy sites of all management treatments.

On the shallow site of the nongrazed treatment, Scarlet globemallow was present during 68.4% and 26.9% of the years that density and basal cover data were collected with a mean 0.55 stems/m^2 density and a mean 0.07% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 100.0% and 83.3% of the years with a mean 1.40 stems/m^2 density and a mean 0.23% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 57.1% and 6.7% of the years with a mean 0.24 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the shallow site of the nongrazed treatment over time (tables 7, 8, and 9).

On the shallow site of the ungrazed seasonlong treatment, Scarlet globemallow was present during 5.0% and 3.8% of the years that density and basal cover data were collected with a mean 0.04 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Scarlet globemallow was present during 6.7% and 6.7% of the years with a mean 0.05 stems/m^2 density and a mean 0.001% basal cover, respectively. The percent present, stem density, and basal cover increased slightly on the shallow site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed seasonlong treatment, Scarlet globemallow was present during 55.0% and 38.5% of the years that density and basal cover data were collected with a mean 0.33 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 20.0% and 66.7% of the years with a mean 0.38 stems/m^2 density and a mean 0.20% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 66.7% and 33.3% of the years with a mean 0.31 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present for the density data increased, and the percent present for the basal cover data, stem density and basal cover decreased on the shallow site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the shallow site of the grazed seasonlong than those on the shallow site of the ungrazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Scarlet globemallow was present during 90.9% and 48.3% of the years that density and basal cover data were collected with a mean 0.51 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 globemallow was present during 100.0% and 88.9% of the years with a mean 0.81 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 86.7% and 33.3% of the years with a mean 0.37 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present, stem density, and

basal cover all decreased on the shallow site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the shallow site of the grazed twice-over treatment, Scarlet globemallow was present during 72.7% and 33.3% of the years that density and basal cover data were collected with a mean 0.25 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 globemallow was present during 71.4% and 40.0% of the years with a mean 0.24 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 73.3% and 26.7% of the years with a mean 0.25 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present for the density data and density remained similar and the percent present for the basal cover data and basal cover decreased on the shallow site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present and stem density were greater on the shallow site of the ungrazed twice-over treatment than those on the shallow site of the grazed twice-over treatment and the basal cover was similar on the shallow site of the ungrazed and grazed twice-over treatments.

During the 30 year period on the shallow sites, Scarlet globemallow stem density and basal cover was low but greatest on the nongrazed treatment and lowest on the ungrazed seasonlong treatment.

On the silty site of the nongrazed treatment, Scarlet globemallow was present during 78.9% and 50.0% of the years that density and basal cover data were collected with a mean 1.36 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 globemallow was present during 80.0% and 66.7% of the years with a mean 2.04 stems/m^2 density and a mean 0.07% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 78.6% and 46.7% of the years with a mean 1.11 stems/m^2 density and a mean 0.05% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the silty site of the nongrazed treatment over time (tables 7, 8, and 9).

On the silty site of the ungrazed seasonlong treatment, Scarlet globemallow was present during 40.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.19 stems/m^2 density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 60.0% of the years density data were collected with a mean 0.38 stems/m^2 density and was not present where basal cover data were collected. During the later period (1998-2012), Scarlet globemallow was present during 33.3% and 13.3% of the years with a mean 0.12 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present for the density data and density decreased and the percent present for the basal cover data and basal cover increased on the silty site of the ungrazed seasonlong treatment over time (tables 7, 8, and 9).

On the silty site of the grazed seasonlong treatment, Scarlet globemallow was present during 50.0% and 30.8% of the years that density and basal cover data were collected, with a mean 0.54 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 globemallow was present during 100.0% and 100.0% of the years, with a mean 1.66 stems/m^2 density and a mean 0.23% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 33.3% and 6.7% of the years, with a mean 0.16 stems/m^2 density and a mean 0.001% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the silty site of the grazed seasonlong treatment over time (tables 7, 8, and 9). The percent present, stem density, and basal cover were greater on the silty site of the grazed seasonlong treatment than those on the silty site of the ungrazed seasonlong treatment, except the percent present, and basal cover during the later period was greater 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, Scarlet globemallow was present during 100.0% and 93.1% of the years that density and basal cover data were collected with a mean 3.14 stems/m^2 density and a mean 0.31% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 100.0% and 100.0% of the years with a mean 5.29 stems/m^2 density and a mean 0.70% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 100.0% and 93.3% of the years with a mean 3.45 stems/m^2 density and a mean 0.05% basal cover, respectively. The percent present remained similar, and stem density and basal cover decreased on the silty site of the ungrazed twice-over treatment over time (tables 7, 8, and 9).

On the silty site of the grazed twice-over treatment, Scarlet globemallow was present during 100.0% and 96.7% of the years that density and basal cover data were collected with a mean 3.64 stems/m^2 density and a mean 0.17% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Scarlet globemallow was present during 100.0% and 100.0% of the years with a mean 4.20 stems/m^2 density and a mean 0.33% basal cover, respectively. During the later period (1998-2012), Scarlet globemallow was present during 100.0% and 100.0% of the years with a mean 3.37 stems/m^2 density and a mean 0.07% basal cover, respectively. The percent present remained similar and the stem density and basal cover decreased on the silty site of the grazed twice-over treatment over time (tables 7, 8, and 9). The percent present were similar on the silty site of the ungrazed and grazed twice-over treatments. Stem density on the silty site was greater during the 30 year period on the grazed twice-over treatment and greater during the early and later periods on the ungrazed twice-over treatment than those on the reciprocal twice-over treatment. Basal cover on the silty site was greater during the 30 year period and early period on the ungrazed twice-over treatment and greater during the later period on the grazed twice-over treatment than those on the reciprocal twice-over treatment.

During the 30 year period on the silty sites, stem density and basal cover were greatest on the ungrazed and grazed twice-over treatments and lowest on the ungrazed and grazed seasonlong treatments.

Scarlet globemallow was present on the sandy sites during 39.7% and 21.1% of the years with a mean 0.21 stems/m^2 density and a mean 0.01% basal cover, it was present on the shallow sites during 58.4% and 30.2% of the years with a mean 0.33 stems/m^2 density and a mean 0.03% basal cover, and it was present on the silty sites during 73.8% and 55.8% of the years with a mean 1.77 stems/m^2 density and a mean 0.11% basal cover, respectively. The percent present, stem density, and basal cover all were greatest on the silty sites and all were the lowest on the sandy sites. Scarlet globemallow grows best on the silty sites.

Scarlet globemallow was not present during the drought growing season of 1988 on the sandy sites of the nongrazed, ungrazed seasonlong, and grazed twice-over treatments, and was present on the grazed seasonlong and ungrazed twice-over treatments. Scarlet globemallow was not present during 1988 on the shallow and silty sites of the ungrazed seasonlong treatment and was present on the nongrazed, grazed seasonlong, and ungrazed and grazed twice-over treatments. Scarlet globemallow has a drought tolerance on the shallow and silty sites.

Scarlet globemallow was present on the sandy sites of the not grazed treatments during 26.7% and 12.8% of the years that density and basal cover data were collected with a mean 0.09 stems/m^2 density and a mean 0.004% basal cover and was present on the sandy sites of the grazed treatments during 59.2% and 33.6% of the years with a mean 0.40 stems/m^2 density and a mean 0.02% basal cover.

Scarlet globemallow was present on the shallow sites of the not grazed treatments during 54.8% and 26.4% of the years that density and basal cover data were collected with a mean 0.37 stems/m^2 density and a mean 0.03% basal cover and was present on the shallow sites of the grazed treatments during 63.9% and 35.9% of the years with a mean 0.29 stems/m^2 density and a mean 0.04% basal cover.

Scarlet globemallow was present on the silty sites of the not grazed treatments during 73.0% and 51.6% of the years that density and basal cover data were collected with a mean 1.56 stems/m^2 density and a mean 0.11% basal cover and was present on the silty sites of the grazed treatments during 75.0% and 63.7% of the years with a mean 2.09 stems/m^2 density and a mean 0.11% basal cover.

The percent present, stem density, and basal cover were greater on the sandy, shallow, and silty sites of the grazed treatments than those on the not grazed treatments except the stem density on the shallow sites of the not grazed treatments was greater than that on the grazed treatments. A reason for the greater abundance of Scarlet globemallow on the grazed treatments is, at least partly, the result of shade intolerance of Scarlet globemallow. Another reason for the greater abundance of Scarlet globemallow on the grazed treatments would be for the greater quantities of available essenital elements in the soils that result from partial defoliation of grass tillers in vegetative growth stages.

Discussion

Scarlet globemallow, *Sphaeralcea coccinea*, is a native, late succession, warm season, perennial forb of the mallow family that is present at usually low abundance on healthy mixed grass prairie plant communities. Scarlet globemallow can grow on sandy, shallow, silty, and clayey ecological sites. It appears to grow best on the silty sites and to grow

poorly on the sandy sites. Annual aerial growth are stems arising from a persistent woody caudex with a spreading rhizome system and a deep taproot with an extensive lateral root system. The flowers have 5 showy petals of deep orange to salmon color that form in dense clusters. The mean first flower date is 13 June (1955-1962 study) with a long nine week flower period from early June to early August (1969-1971 study) and with observed flowers from early June to late July (1984-1985 study). Many stems (82.1%) did not produce flowers and remained vegetative (1984-1985 study). Mean stem height was 11.8 cm (4.6 in) (1955-1962 study) and 11.0 cm (4.3 in) (1984-1985 study) during late June and July. Mean stem weight was 0.23 g (1984-1985 study). The percent present, stem density, and basal cover was greatest on the silty sites and lowest on the sandy sites. The percent present, stem density, and basal cover was greater on the grazed treatments than those on the not grazed treatments. Scarlet globemallow is extremely drought tolerant, more so on the silty and shallow sites than on the sandy sites and is shade intolerant primarily on the not grazed treatments.

The woody caudex, spreading rhizome system, and deep taproot with an extensive lateral root system help Scarlet globemallow to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Scarlet globemallow, Sphaeralcea coccinea.

	Apr	May	Jun		Jul		Aug		Sep
First Flower									
1955-1962									
Earliest			4						
Mean			13						
Flower Period									
1969-1971			XX	XX	XX	XX	X		

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

Table 2. Autecology of Scarlet globemallow, Sphaeralcea coccinea, 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	10.0	13.0	11.8		52.1	85.9	100.0		

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Scarlet globemallow, Sphaeralcea coccinea, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	74.2	79.8	89.3	94.1	73.6	75.3
Bud	18.2	10.1	6.7	2.9	10.4	3.2
Anth	7.6	2.5	0.7			
Seed Dev		5.9	2.7		6.6	4.3
Seed Shed		1.7		1.5	9.4	
Mat			0.7	1.5		17.2
Mean Height (cm)						
Veg	6.8	6.6	6.9	7.4	6.4	7.0
Bud	10.5	8.9	8.6	9.7	8.6	4.6
Anth	14.6	11.4	9.4			
Seed Dev		13.1	9.1		10.5	8.3
Seed Shed		13.3		9.1	7.1	
Mat			10.3	9.3		8.4
% Dryness						
Veg	4.3	3.8	10.4	20.1	19.8	14.3
Bud	0.3	2.3	1.0	7.3	3.9	2.0
Anth	5.0	0.0	2.0			
Seed Dev		11.9	25.0		32.1	19.3
Seed Shed		25.0		37.5	35.2	
Mat			50.0	25.0		22.5
Mean Weight (g)	0.56	0.29	0.25	0.25	0.18	0.16

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

Table 4. Phenological growth stage changes during the growing season for Scarlet globemallow, Sphaeralcea coccinea, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	72.2	80.0	83.6	91.7	85.7	75.4
Bud	18.1	13.1	8.6	4.9	4.8	2.6
Anth	6.9	2.1		0.7		
Seed Dev	2.8	2.8	0.7		1.6	1.8
Seed Shed		1.4	5.3		0.8	1.8
Mat		0.7	2.0	2.8	7.1	18.4
Mean Height (cm)						
Veg	7.4	5.7	5.8	6.3	6.1	6.5
Bud	8.2	7.6	4.9	7.1	6.9	6.3
Anth	11.8	8.2		10.3		
Seed Dev	12.9	10.9	9.6		8.2	11.1
Seed Shed		9.3	10.7		5.1	7.4
Mat		8.2	12.0	8.9	7.8	8.3
% Dryness						
Veg	1.4	4.6	6.3	15.1	15.5	18.1
Bud	0.9	0.9	3.6	15.2	9.7	21.2
Anth	0.8	0.7		2.0		
Seed Dev	0.0	19.3	25.0		37.5	13.5
Seed Shed		13.5	40.6		50.0	50.0
Mat		25.0	41.7	43.8	22.7	24.2
Mean Weight (g)	0.19	0.16	0.19	0.17	0.15	0.14

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

Table 5. Phenological growth stage changes during the growing season for Scarlet globemallow, Sphaeralcea coccinea, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	82.5	79.7	88.3	90.7	85.3	75.9
Bud	13.8	15.1	6.4	2.7	4.0	7.5
Anth	3.8	2.1	0.6	0.7		
Seed Dev		2.6	1.8	0.7	1.3	2.3
Seed Shed		0.5	2.3	2.0	2.7	
Mat			0.6	3.3	6.7	14.3
Mean Height (cm)						
Veg	7.9	7.3	7.4	7.2	7.4	7.2
Bud	11.2	9.3	8.7	7.8	6.2	7.8
Anth	12.4	14.7	5.9	13.2		
Seed Dev		11.6	10.8	10.1	13.7	9.5
Seed Shed		12.0	9.3	10.4	10.9	
Mat			8.1	9.7	8.5	10.1
% Dryness						
Veg	2.1	3.1	11.3	10.7	13.2	14.5
Bud	5.7	2.5	0.9	2.0	9.7	25.8
Anth	0.7	0.0	2.0	2.0		
Seed Dev		20.8	17.3	25.0	25.0	25.0
Seed Shed		2.0	37.5	25.0	38.0	
Mat			25.0	20.8	20.8	29.4
Mean Weight (g)	0.25	0.22	0.27	0.29	0.21	0.19

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

Table 6. Phenological growth stage changes during the growing season for Scarlet globemallow, Sphaeralcea coccinea, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	91.2	75.5	84.2	87.9	77.2	77.0
Bud	8.8	13.6	10.0	2.2	7.6	6.8
Anth		1.8	1.7			
Seed Dev		8.2	3.3	5.5	3.8	
Seed Shed		0.9	0.8			
Mat				4.4	11.4	16.2
Mean Height (cm)						
Veg	7.4	6.2	7.0	6.9	6.9	6.5
Bud	8.1	9.0	9.6	9.0	7.5	6.0
Anth		12.9	7.8			
Seed Dev		12.6	15.4	12.5	8.0	
Seed Shed		5.1	8.3			
Mat				9.4	8.8	10.8
% Dryness						
Veg	4.7	5.6	8.0	16.5	12.1	23.9
Bud	0.8	6.2	1.0	37.5	5.5	6.2
Anth		0.0	1.0			
Seed Dev		4.1	7.3	15.8	9.7	
Seed Shed		25.0	2.0			
Mat				37.5	30.6	31.6
Mean Weight (g)	0.36	0.24	0.23	0.21	0.19	0.17

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

Table 7. Autecology of Sphaeralcea coccinea, Scarlet globemallow, with growing season changes in density importance value, 1983-2012.

Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	1.04	0.59	2.22
1988-1992	0.00	0.00	1.74	3.22	0.53
1993-1998	0.00	0.00	0.00	0.00	4.30
1999-2003	0.00	0.00	1.95	0.13	4.16
2004-2009	2.05	0.00	0.00	0.25	4.15
2010-2012	2.79	0.00	0.00	0.73	4.79
Shallow					
1983-1987	7.53	0.00	0.00	4.84	1.17
1988-1992	19.44	0.00	3.61	5.51	2.27
1993-1998	0.00	0.00	0.00	1.91	1.25
1999-2003	2.60	1.08	1.59	0.65	0.66
2004-2009	1.53	0.00	1.80	1.70	1.78
2010-2012	0.00	0.00	4.05	3.09	2.66
Silty					
1983-1987	11.57	2.37	16.71	24.62	17.38
1988-1992	14.82	1.67	15.50	56.92	58.35
1993-1998	1.06	0.00	0.00	40.56	39.98
1999-2003	1.97	0.75	1.38	19.73	17.64
2004-2009	5.32	0.35	0.18	18.80	23.55
2010-2012	16.30	1.38	0.00	36.75	33.67

Table 8. Autecology of Sphaeralcea coccinea, Scarlet globemallow, 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	0.08	0.05
1988-1992	0.00	0.00	0.48	0.46	0.96
1993-1998	0.00	0.00	0.00	0.18	0.16
1999-2003	0.00	0.00	0.09	0.00	0.03
2004-2009	0.06	0.00	0.00	0.03	0.29
2010-2012	0.00	0.00	0.00	0.00	0.16
Shallow					
1983-1987	4.21	0.00	0.26	0.39	0.11
1988-1992	1.92	0.00	2.29	0.78	0.36
1993-1998	0.62	0.00	0.08	0.04	0.49
1999-2003	0.00	0.02	0.06	0.03	0.04
2004-2009	0.12	0.00	0.10	0.06	0.04
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.41	0.00	1.95	2.66	1.33
1988-1992	1.26	0.00	1.70	8.33	4.19
1993-1998	0.19	0.12	0.12	3.26	1.43
1999-2003	0.08	0.00	0.02	0.58	0.59
2004-2009	0.35	0.00	0.00	0.57	0.59
2010-2012	0.65	0.04	0.00	0.35	0.17

Table 9. Autecology of Sphaeralcea coccinea, Scarlet globemallow, with growing season changes in density, 1983-2012.

Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.01	0.01	0.02
1988-1992	0.00	0.00	0.03	0.05	0.01
1993-1998	0.00	0.00	0.00	0.00	0.06
1999-2003	0.00	0.00	0.05	0.00	0.08
2004-2009	0.03	0.00	0.00	0.01	0.08
2010-2012	0.03	0.00	0.00	0.01	0.08
Shallow					
1983-1987	0.12	0.00	0.00	0.13	0.02
1988-1992	0.15	0.00	0.05	0.05	0.03
1993-1998	0.00	0.00	0.00	0.03	0.02
1999-2003	0.03	0.02	0.05	0.02	0.01
2004-2009	0.03	0.00	0.03	0.05	0.03
2010-2012	0.00	0.00	0.05	0.05	0.04
Silty					
1983-1987	0.22	0.11	0.35	0.54	0.43
1988-1992	0.20	0.02	0.12	0.52	0.42
1993-1998	0.02	0.00	0.00	0.49	0.51
1999-2003	0.06	0.04	0.02	0.23	0.31
2004-2009	0.12	0.01	0.01	0.14	0.30
2010-2012	0.20	0.01	0.00	0.24	0.40

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