COMBINED EFFECTS OF ENVIRONMENTAL AND AGRONOMIC FACTORS ON THE INVASION PATTERNS OF SPHAERALCEA COCCINEA (NUTT.) RYDB. (MALVACEA)[1]

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ABSTRACT

The invasion of scarlet globemallow (Sphaeralcea coccinea (Nutt.) Rydb. (Malvacea)) onto an area of reseeded vegetation was studied. A chi-square analysis was used to determine the effect of certain agronomic and environmental factors. The environmental factors of SAR and available soil moisture, and the agronomic factor of seed mixture, were shown to have a significant effect on the invasion of this species.

INTRODUCTION and LITERATURE REVIEW

Scarlet globemallow or red falsemallow (Sphaeralcea coccinea (Nutt.) Rydb. (Malvacea)) is a native, perennial forb of the Malvacea family (LaDuke and Northington 1978). Early taxonomists referred to this species as Malvastrum coccineum (Pursh.) A. Gray (Britton and Brown 1897). Britton and Brown also cite earlier references to this species: Malva coccinea Nutt. in Fraser's Cat. Name Only. 1813: and, Cristaria coccinea Pursh. Fl. Am. Sept. 454. 1814.

The genus name Sphaeralcea was derived from the Greek sphaira, a sphere and alkea, mallow, referring to the rounded head of the fruit (Gleason 1952). Plants are between 7 and 30 cm in height and arise from a woody taproot (Rydberg 1922, Taylor 1972). The leaves are greyish-green in color (South Dakota State University 1970), alternate with palmately lobed or dissected blades (Gleason 1952), and are covered with stellate silvery hairs (Rydberg 1965). Rydberg (1965) also described the flowers as subtended by one to three bractlets, with five partially united sepals, and five petals. He further stated that the flowers generally occur in terminal spike-like racemes and can appear in a range of colors from light pink to brick red.

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Most authors agree with Rydberg's (1906) description of the geographic distribution of this species. He reported that this species occurred from Saskatchewan and Oregon to across the Great Plains into Iowa, and south to Texas and Mexico. It could generally be found in these areas at an altitude between 1300 and 3000 m in dry, sandy soils and in habitats ranging from pastures to sagebrush-juniper sites.

Chromosome studies of this species have shown polyploids of 2n=20 and 30 (LaDuke 1982). It was also stated that literature on this species was lacking because of its high degree of morphological variation, polyploidy, and hybridization. Scarlet globemallow is generally known to display ecotypic variation. Ward et al. (1982), however, stated that plants collected from different elevations in the Piceance Basin of Colorado did not display significantly different ecotypic variation.

Flowers appear between May and August, although flowering will continue into late September (South Dakota State University 1970). The carpels occur on racemes and are arranged in groups of five to nine and form a sphere that measures 2-4 mm in diameter (Britton and Brown 1897, Gleason 1952, Rydberg 1965).

This species is considered to be highly drought resistant and will shed its leaves during these dry periods (South Dakota State University 1970). It has also been noted that this species has a tendency to increase during periods of drought and overgrazing (South Dakota State University 1970).

Scarlet globemallow has been rated fair to poor in palatability although it is commonly eaten by livestock and is considered an important forage species in some arid regions (South Dakota State University 1970, Regelin et al., 1976, Vavra et al. 1977). Hansen (1980) indicated that almost all species of range herbivores have been shown to eat these plants, and even though it does not comprise a major portion of the diet it is still considered to be an important forage species. Flinders (1971) reported that this species comprised an important part of the diet of insects, small mammals, antelope, sheep, and cattle. It is highly digestible and fulfills the requirements of digestible energy and digestible protein for livestock (Taylor 1972). Taylor further reported that the vitamin A content of this species is high during early growth (256,740 I.U./kilogram) and when in bloom (48,180 I.U./kilogram). He also indicated that the magnesium and calcium content of plants has been shown to be low to deficient.

A defoliation study of this species has shown no significant difference between herbage yields of defoliated plants after a 14-month rest period, when compared with control plants (Buwai 1975). This species was further shown to be highly resistant to multiple heavy defoliations. The plants used in the experiment by Buwai showed an excellent recovery after three or six heavy defoliations and then 14 or 26 months of rest. Hyder et al. (1975) reported that the most detrimental response to grazing occurred in May or June, but that the plants appeared to benefit from grazing in August or December. In addition to its value as a forage plant, it is imbued with medicinal properties. Gilmore (1977) referred to scarlet globemallow as the "... medicine of the heyoka." He reported that the Dakota Indians were known to chew certain parts of the plant to form a paste, and then apply this paste to flesh wounds. Application of this same paste to the hands would enable the user to immerse his fingers into boiling water to retrieve meat without scalding his fingers.

MATERIALS and METHODS

Scarlet globemallow was selected as one of 10 invading species to be studied on a reseeded site in the Piceance Basin of northwestern Colorado (Grygiel 1983). The Piceance Basin is a semiarid tract of land of approximately 3200 km^2. The study was conducted on the Shallowly Disturbed Successional Study located at the Colorado State University Intensive Study Site in the Piceance Basin. Elevation at the study site was 2040 m. Annual precipation for the years studied was: 22.33 cm in 1979, 28.65 cm in 1980, and 33.49 cm in 1981. The soil present on the site was classified by a representative of the Soil Conservation Service as belonging to the Yamac Series.

The Shallowly Disturbed Successional Study site was established in September and October of 1976. The disturbance consisted of scalping the site with a D-8 Caterpillar tractor and then ripping the soil to a depth of 30 cm. The 2.5-ha study area was divided into 108 subplots, which were drill seeded with one of six seed mixtures as follows: Native grass seed mixture, Introduced grass seed mixture, Native grass-forb seed mixture, Introduced grass-forb seed mixture, Native grass-forb-shrub seed mixture, and Native and Introduced grass-forb-shrub seed mixture. Three levels of nitrogen and phosphorus fertilizer were applied at the following rates: 112 kg N/ha and 56 kg P/ha, 56 kg N/ha and 28 kg P/ha, and 0 kg N/ha and 0 kg P/ha. Each subplot had dimensions of 9x18 m.

The data were analyzed with detrended correspondence analysis (DCA) (Hill 1979) which identified the environmental factors of SAR (sodium absorption ratio) of the soil, available soil moisture, and wind dispersal of reproductive propagules (wind drift). Chi-square analysis was then employed to determine if invasion was evenly distributed among the agronomic factors of fertilizer and seed mixture, as well as the environmental factors of SAR level of soil, available soil moisture, and wind dispersal of plant propagules.

Thirty-six subplots were mapped each year during the sampling periods of 1979, 1980, and 1981. Eighteen of the mapped subplots had been seeded with the Native grass-forb-shrub seed mixture and eighteen had been seeded with the Native and Introduced grass-forb-shrub seed mixture.

Invasion pattern mapping consisted of dividing the subplots into 1-m^2 sections, by means of a string grid, and mapping the area occupied by the invading species which occurred in the 1-m^2 area. The area occupied by the plants was then sketched to scale onto a grid that corresponded to the 1-m^2 divisions of the subplot. The express purpose of this technique was to record the change in distributional pattern of the plants through time. The method used in this study was a modification of a mapping procedure described by Pickford and Stewart (1935).

RESULTS and DISCUSSION

Fertilizer was not shown to be a significant ($p < 0.05$) factor. Seed mixture and certain environmental factors were all shown to have a significant effect on the biomass production of scarlet globemallow.

The biomass production of scarlet globemallow was uniformly distributed among all seed mixtures during the 1978 sampling period. During the 1979 sampling period, however, it was shown to have significantly lower ($p < 0.05$) biomass levels in the Introduced grass seed mixture, Native grass-forb seed mixture, and Introduced grass-forb seed mixture as compared with the other three seed mixtures.

The 1981 sampling period also showed a significant difference ($p < 0.05$) in biomass production among seed mixtures. The Introduced grass seed mixture showed the lowest evidence of invasion by this forb on the study site. The Native grass seed mixture was readily invaded by scarlet globemallow and especially in those subplots which were located in areas of high moisture. Invasion levels of the Native grass-forb seed mixture and the Introduced grass-forb seed mixture were not significantly different ($p > 0.05$) from each other. The Native grass-forb-shrub seed mixture had an invasion level comparable to the Native grass seed mixture for 1981. Invasion in this seed mixture was a reflection of the presence of native grasses and the small patches of open areas which occurred around seeded fourwing saltbush (_Atriplex argentea_) Nutt. plants.

The relatively high levels of biomass production that occurred in 1981 in the Native grass-forb-shrub seed mixture was the result of biomass production in a few, isolated subplots. These particular subplots were subject to the influence of the high soil moisture levels. In addition, the Native grass-forb-shrub seed mixture supported the highest level of invading species for 1979. The comparatively high incidence of invasion that occurred in the Native grass-forb-shrub seed mixture may have resulted from spaces left open by those seeded shrub and forb species which showed a poor response. Seeded species which showed a relatively poor response in this mixture were emerald crownvetch (_Coronilla varia_ L.), Stansbury cliffrose (_Cowania mexicana stansburiana (Torr.)_), and green ephedra (_Ephedra viridis (Colville)_).

Soil moisture was shown to be the most important environmental factor during all three sampling periods (Table 1). The data also illustrated the propensity for scarlet globemallow to be located in areas of high moisture. Wind dispersal was not shown to be a significant factor ($p < 0.05$) because the species showed a tendency to reproduce by rhizomes and its seeds are not morphologically designed for wind dissemination. A high SAR level in the subplots did not result in a significant biomass production of this species.

The maps selected for discussion in this paper are representative of the invasion pattern of scarlet globemallow as these patterns occurred over the study site in the Native grass-forb-shrub seed mixture and in the Native and Introduced grass-forb-shrub seed mixture. The map shown is of an individual subplot, but it typifies the distribution pattern of this species in these seed mixtures (Figure 1.). The 1979 distribution of scarlet globemallow took the form of seedlings and relatively small, mature plants grouped together in the formation of islands of vegetation. These islands became smaller in size in 1980 as the less competitive seedlings relinquished territory to the larger plants. The diminutive islands of 1980 had fragmented to form colonies of parent plants and their progeny during the 1981 growing season. This species was shown to be prolifically rhizomatous in its reproductive strategy. It was not unusual to excavate seedlings connected by rhizomes to parent plants which were located at a distance of up to 1 m. This species has a woody taproot, and seedlings will have a great portion of their biomass concentrated beneath the soil surface.

Scarlet globemallow was shown to be an early invading species capable of infiltrating recently disturbed reseeded areas. Additional observations of the species as it occurred in the native vegetation showed a similar response. In disturbed, non-seeded areas scarlet globemallow appeared as a major early invading species. It appeared in clumps, rather than in uniform distribution. A parent plant in association with satellite progeny reflected the rhizomatous mode of reproduction. Although this species exhibited prolific seed production when moisture was abundant, fewer seeds were produced during those years when there was less available moisture.

Germination test results were poor and it was concluded that a hard seed coat was a factor which contributed to the poor germination response. Subsequent germination tests were conducted after subjecting the seed to various degrees of acid and mechnical scarification and confinement in a germinator. Although germination response was not greatly increased by any of the treatments, it was shown that a higher intensity of scarification produced a higher germination response. Greenhouse and field germination studies conducted with the scarified seed proved inconclusive at this writing.

Field observations in native vegetation and maps drawn of the reseeded site indicated that the prominence of this species becomes

Table 1. Percentage of total biomass of Sphaeralcea coccinea affected by individual environmental factors.

Sampling Period	Environmental Factor	Percent of Total Biomass†	
		Observed	Expected
1978	Moisture	59	48
1979		63	48
1981		67	48
1978	Wind drift	19	25
1979		20	25
1981		19	25
1978	SAR	14	16
1979		9	16
1981		8	16
1978	Neutral	8	11
1979		8	11
1981		6	11

†The hypothesis of "even" biomass distribution ("even" in terms of proportional to the number of sub-subplots in each sector) was rejected with $P<0.05$ for the three sampling periods.

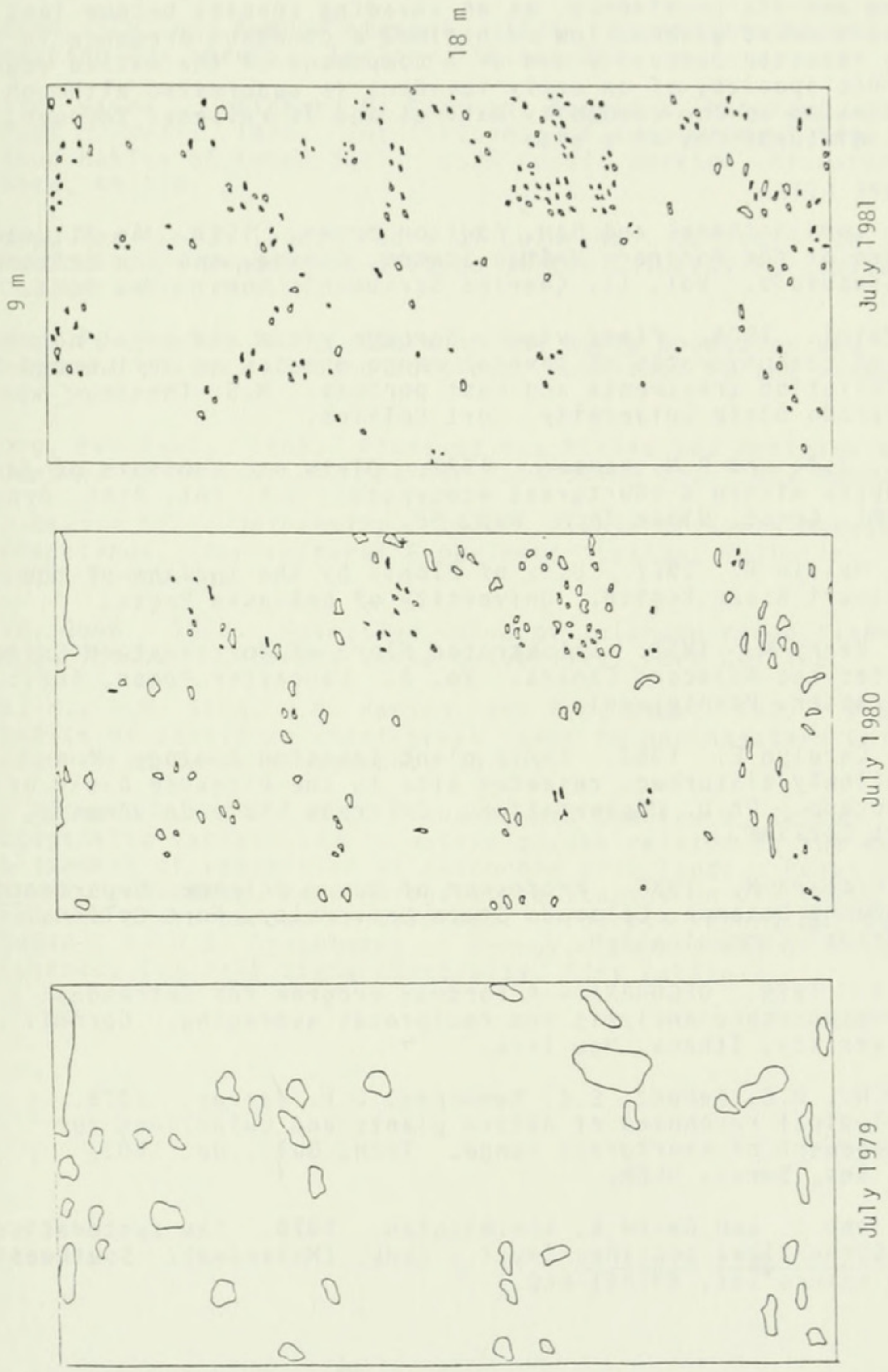

Figure 1. Distributional pattern outlines of *Sphaeralcea coccinea* for three data collection periods.

less as the plant community matures. This species will apparently aggressively invade an open area but it will not aggressively compete with established plants, especially grasses. Although plant density decreased and its prominence as an invading species became less apparent, scarlet globemallow maintained a constant presence in the maturing reseeded community and as a component of the native vegetation. This species, as an early invader, is suppressed although not eliminated as the community matures and is released through physical disturbances of a site.

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