Plants Emerging from Soils Under Three Range Condition Classes of Desert Grassland

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Highlight: This research was conducted to determine emergence of seedlings from surface soil collected on black grama (*Bouteloua eriopoda*) grassland sites in good, fair, and poor condition classes. The species that emerged and their numbers were compared to the species actually found on the field locations. The following conclusions were drawn: (1) The fair condition site had more seedlings emerge than the other two and of these seedlings by far the most were grasses; (2) Mesa dropseed (*Sporobolus flexuosus*) was the most abundant grass species emerging from collected soil for all three condition classes, but it was much more abundant from fair condition soil; (3) Though black grama dominated the good condition range, emergence of black grama seedlings in the greenhouse from collected soil was much below expectations; (4) More plant species occurred in the field than emerged from collected soils; (5) Secondary successional patterns cannot be predicted accurately from techniques used in this study; (6) Mesa dropseed appears to be a key mid-successional species, filling a broad niche from low good to low fair range condition.

The Desert Grassland is an important rangeland area in the southwestern United States, but unfortunately overgrazing and frequent drought have combined to reduce its overall biological productivity greatly.

Secondary succession, the natural process by which given range sites progress from a deteriorated ecological stage (poor range condition) to an improved stage nearer its ecological potential (good and excellent range condition) is largely dependent upon the seeds available for germination. These seeds reflect either real or potential stages of secondary succession and thus provide an index to what may occur when environmental conditions are right for their germination. Understanding the dynamics of a plant community requires some knowledge of the viable seeds in the soil. We must assume that succession of seeds takes place underground much as succession of plants takes place above.

The numbers of seeds in reserve on most range sites are large. Dye (1969) reported 13,000 seeds per m^2 on one site and 22,000 on a second. Major and Pyott (1966) showed similar numbers, 15,200 to 22,700 seeds per m^2 in California annual grasslands.

Germination is a complex physiological process and the correct combination of conditions could never exist at one time that would permit germination of all seeds present. Soil moisture is perhaps the most critical single factor limiting germination in arid and semiarid environments.

The objective of this study was to determine the number and species of plants emerging from buried seed in soil collected from three range condition classes of a Deep Sand Range Site as classified by the Soil Conservation Service (U.S.D.A. 1967).

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Study Area

The location of this study was on the Desert Grassland vegetation type about 50 km (24 miles) north of Las Cruces, New Mexico. It is classed as semidesert with an average annual precipitation of 225 mm (9.0 inches). About half the precipitation occurs during July, August, and September. The topography of the study area is typical of the range site it represents, being generally level to gently undulating with slopes rarely exceeding 5%. The elevation is 1,310 m (4,300 ft). The range site is classified as Deep Sand with coarse textured surface soils and loose open subsoils (USDA 1967). It is subject to severe wind erosion. Winter intake rates are rapid and water holding capacity is low.

Within this Deep Sand Range Site, three range condition classes were studied: Good condition range was dominated by black grama (*Bouteloua eriopoda*)[1], fair condition dominated by mesa dropseed (*Sprorobolus flexuosus*), and poor condition dominated by fluffgrass (*Erioneuron pulchellum*) and numerous annual grass and forb species (Valentine 1970). Scattered mesquite plants (*Prosopis juliflora*) and broom snakeweed (*Xanthocephalum sarothrea*) occurred on both the poor and fair condition sites. The range condition classes were designated by the relative proportions of perennial plant species as they compared with the potential species composition of the site. The original vegetation of the Deep Sand Range Site is considered to be dominated by black grama typical of much of the Desert Grassland range of the Southwest (USDA) 1967.

Methods

Twenty soil samples were systematically collected from each of the three range condition classes to a depth of 2 cm from an area of about two hectares (5 acres) for each condition class. Areas were selected as being typical of rangeland representing approximately the mid-point of each condition class with regard to its ecological potential. None of the sites showed significant soil erosion, even the poor condition site. Soil samples from each condition class were thoroughly mixed and air-dried. The collected soil was placed uniformly 2 cm deep over sterile sand in containers 20 cm in diameter and 30 cm tall.

The soil collections from the three range condition classes were watered as needed to maintain soil water near field capacity in all pots. Treatments were replicated four times in a completely randomized block design and conducted in a greenhouse.

Plants that emerged from each treatment were identified and recorded daily. Records were kept for 2 months, March 26-May 26, 1971. When identified, the seedlings were removed from the containers. Otherwise, the plants grew until identification was possible.

In mid-August, 2 weeks following the first summer rains, vegetation on the field locations was sampled to determine plant density and species composition based on plant numbers. Fifty square-meter quadrats were systematically located and sampled over the two hectares representing each of the three range condition classes. These data were used to compare plants present in the field with plants emerging in the greenhouse.

Where appropriate, data were analyzed using ANOVA procedures as outlined by Steel and Torrie (1960). Temperature was

[1] Plant names generally follow Kearney and Peebles 1964. Exceptions follow Gould 1975.

continuously recorded in the greenhouse. Daily minimum temperature during the study varied from 16-21° C (60°-70° F) between 4:00 and 6:00 a.m. to a maximum of 27-32° C (80°-90° F) between 11:00 a.m. and 1:00 p.m. Temperatures of the soil surface in the greenhouse pots averaged 26°C (78°F) at 1:00 p.m.

Soil pH from each location was not significantly different for each of the locations.

Results

Plant Emergence in the Greenhouse

At the end of 2 months' observation, total emergence of grasses and forbs showed significant differences ($P < .05$) between range condition classes (Table 1). The large number of grass plants emerged from soil collected from fair condition range. Emergence of grass plants was greater in soil from poor than in good condition range (Table 1). In the case of forbs, more emerged from poor condition soil than either fair or good; and there was no difference between the good and fair condition classes. The major shrub species on the study area were broom snakeweed and mesquite, but no seedlings of these species appeared from any collected soil.

Mesa dropseed (*Sporobolus flexuosus*) was the most abundant grass species emerging from the collected soil in all three condition classes (Table 1). However, plant numbers of mesa dropseed were by far greatest in fair condition with 645.8 plants per m², representing 94% of the grass plants emerging. For good and poor condition, mesa dropseed made up 50% and 54%, respectively, of total grass plants. Russian thistle (*Salsola kali*), an annual, was the most common forb appearing from the soil representing all three range condition classes (Table 1).

For the soil collected from the good condition site, 284 total plants emerged per m² representing 104 grass plants and 180 forb plants (Table 1). Total grass plants emerging from the fair condition site numbered 687 per m² while the forb number was 125 for a total of 812 plants. For poor condition these numbers were 195 and 291, respectively, totaling 486 (Table 1). Ten different species emerged, four grass and six forb, from the seed contained in fair condition soil and 12 species, five grass and seven forb species, from poor condition (Table 1). For good condition nine species, five grass and four forb, emerged from the collected soil.

Greenhouse Emergence vs Range Location

Plant emergence from collected soil was compared to numbers and species of plants occurring in the field for each range condition class (Table 1). In all cases there were more species occurring in the field than emerged in the greenhouse

Table 1. Average number of seedlings (no/m²) emerging from soil collected from three range condition classes under field capacity, greenhouse conditions compared with numbers of plants occurring on the range.

Species	Annual (A) perennial (P)	Good condition		Fair condition		Poor condition	
		Greenhouse	*Range*	*Greenhouse*	*Range*	*Greenhouse*	*Range*
Grasses							
Aristida adscencionis	A	6.9	0	6.9	0	41.7	0
A. longiseta	P	0	1.9	0	0.4	0	4.4
Bouteloua eriopoda	P	13.9	40.4	0	10.1	0	1.6
B. aristidoides and/or *B. barbata*[1]	A	6.9	26.1	6.9	11.0	13.9	10.2
Enneapogon desvauxii	P	0	0	0	0	6.9	0
Erioneuron pulchellum	P	13.9	40.7	27.8	22.2	27.8	32.9
Panicum capillare	A	0	1.3	0	4.1	0	0.5
Sporobolus flexuosus	P	62.5	2.4	645.8	56.6	104.2	3.6
Total Grasses		104.1 c[2]	112.8 c	687.4 a	104.4 c	194.5 b	53.2 d
Forbs							
Allionia incarnata	P	0	4.9	0	3.5	0	4.6
Amaranthus palmeri	A	0	0.2	0	1.5	0	0.2
Aphanostephus humilis	A	6.9	0.5	0	0	0	0
Aplopappus gracilis	A	0	0	0	0	6.9	0
Boerhaavia torreyana	A	0	0	13.9	0	0	1.7
Cassia bauhinoides	P	0	0.7	0	5.7	0	3.0
Chenopodium album	A	34.7	1.7	6.9	6.6	13.9	7.4
Croton corymbulosus	P	0	0.9	0	0.2	6.9	5.2
Dithyrea wislizenii	P	0	0	0	0.2	0	0
Eriogonum albertianum	A	0	0.2	0	0.1	0	0.4
Euphorbia camaesyce	A	0	5.1	0	0.5	0	1.9
Hoffmanseggia densiflora	P	0	0	0	0.6	0	0.2
Kallstroemia hirsutissima	A	0	1.7	0	1.6	0	0.1
Lesquerella fendleri	P	0	0.2	0	0	0	0
Molugo cerviana	A	0	0	0	1.5	0	1.2
Nama hispida	A	0	0	27.8	0	20.8	0
Pectis papposa	A	0	1.2	0	0.1	0	1.1
Portulaca pilosa	A	0	0.6	13.9	16.6	13.9	50.3
Psilostrophe tagetina	P	0	0	0	0.2	0	0.1
Salsola kali	A	76.4	4.9	48.6	5.3	201.4	11.9
Solanum eleagnifolium	P	0	0	0	2.0	0	0.9
Tidestromia lanuginosa	A	62.5	12.5	13.9	9.3	27.8	15.7
Tribulus terrestris	A	0	0.9	0	0.6	0	0.2
Total Forbs		180.5 b	36.2 c	125.0 b	56.1 c	291.6 a	106.1 b
Shrubs							
Prosopis juliflora	P	0	0	0	0.1	0	0
Xanthocephalum sarothrae	P	0	0.1	0	1.6	0	0
Grand total		284.6 c	149.1 d	812.4 a	162.2 d	486.1 b	159.3 d

[1] Cannot differentiate in seedling stage.
[2] Numbers in a row followed by the same letter are not significantly different at the .05 level.

Table 2. Percent species composition of seedlings emerging from soil collected from three range condition classes under field capacity, greenhouse conditions compared with percent species composition of plants occurring on the range.

Species	Good condition		Fair condition		Poor condition	
	Greenhouse %	Range %	Greenhouse %	Range %	Greenhouse %	Range %
Grasses						
Aristida adscencionis	2.4	0	0.8	0	8.6	0
A. longiseta	0	1.3	0	0.2	0	2.8
Bouteloua eriopoda	4.8	27.1	0	6.2	0	1.0
B. aristidoides and/or *B. barbata*[1]	2.5	17.5	0.8	6.8	2.9	6.4
Enneapogon desvauxii	0	0	0	0	1.4	0
Erioneuron pulchellum	4.8	27.4	3.4	14.0	5.7	20.6
Panicum capillare	0	0.8	0	2.5	0	0.3
Sporobolus flexuosus	22.0	1.6	79.6	34.9	21.4	2.2
Total Grasses	36.5	75.7	84.6	64.6	40.0	33.3
Forbs						
Allionia incarnata	0	3.3	0	2.1	0	2.9
Amaranthus palmeri	0	0.1	0	0.9	0	0.1
Aphanostephus ramoisissimus	2.4	0.4	0	0	0	0
Aplopappus gracilis	0	0	0	0	1.4	0
Boerhaavia torreyana	0	0	1.7	0	0	1.1
Cassia bauhinoides	0	0.5	0	3.5	0	1.9
Chenopodium album	12.2	1.1	0.8	4.1	2.9	4.6
Croton corymbulosus	0	0.6	0	0.1	1.4	3.3
Dithyrea wislizenii	0	0	0	0.1	0	0
Eriogonum albertianum	0	0.1	0	T	0	0.2
Euphorbia camaesyce	0	3.4	0	0.3	0	1.2
Hoffmanseggia densiflora	0	0	0	0.4	0	0.1
Kallstroemia hirsutissima	0	1.1	0	1.0	0	T
Lesquerella fendleri	0	0.1	0	0	0	0
Molugo cerviana	0	0	0	0.9	0	0.8
Nama hispida	0	0	3.4	0	4.3	0
Pectis papposa	0	0.8	0	T	0	0.7
Portulaca pilosa	0	0.4	1.7	10.2	2.9	30.6
Psilostrophe tagetina	0	0	0	0.1	0	T
Salsola kali	26.8	3.3	6.0	3.3	41.4	7.4
Solanum eleagnifolium	0	0	0	1.2	0	0.6
Tidestromia lanuginosa	22.0	8.5	1.7	5.7	5.7	9.9
Tribulus terrestris	0	0.6	0	0.4	0	0.1
Total Forbs	63.4	24.3	15.3	34.3	60.0	65.5
Shrubs						
Prosopis juliflora	0			T		T
Xanthocephalum sarothrae	0			1.0	0	1.1

[1] Cannot differentiate in seedling stage.

from collected soil. The same six grass species were found in all three range condition classes in the field but in greatly varying amounts. Numerous forb species were encountered in the field that did not appear in the greenhouse. Perennial grass species having large quantities of seed in the soil were mesa dropseed and fluffgrass (*Erioneuron pulchellum*). Annual grasses such as *Aristida adscencionis* and *Bouteloua* spp. appeared in collected soils but were not present in the field at the time of sampling.

Only annual forb species emerged from the collected soils except for *Croton corymbulosus* in the poor condition. *Salsola kali* was the most numerous forb species found in the field in all three condition classes, followed in order by *Tidestromia lanuginosa* and *Chenopodium album*. Perennial forb numbers were relatively low in the field though several species were present.

Evaluation of total plant numbers showed composition of mesa dropseed was 22% from good condition range in the greenhouse but only 1.6% of the plants occurring from the same condition in the field (Table 2). In fair condition mesa dropseed made up 79.6% and 34.9% of the species composition in the greenhouse and field locations, respectively; and 21.4% and 2.2%, respectively, for poor condition range. Black grama (*Bouteloua eriopoda*), the key species in good condition Desert Grassland, made up 27.1% of the plants occurring in the good condition field site but only 4.8% of the plants emerging from that soil (Table 2).

Aristida adscencionis, an annual, was the second most abundant grass emerging from soil collected on the poor condition location. It had not yet appeared in the field location at the time of sampling.

Forbs made up 63.4% of all plants emerging in the greenhouse from good condition soil and grasses 36.5%. The reverse was observed for the field locations, being 24.3% for forbs and 75.6% for grasses (Table 2). Fair condition soil produced 15.3% forbs and 84.6% grasses, compared to the field location where these percentages were 34.3% and 64.6%, respectively. The poor condition class was the only one having similar percentages of total forb and grass plants emerging in the greenhouse compared with plants occurring in the field location.

Though broom snakeweed and mesquite were visually obvious on the fair and poor condition locations, they made up only about 1% or less of the total plant population.

Discussion and Conclusions

Secondary succession patterns cannot be accurately predicted from the techniques used in this study though some useful inferences can be drawn. There is some relationship between buried seeds and the plants above ground but, supporting Major and Pyott (1966), they are not highly correlated. Duba and Norton (1977) noted that high percentages of the two annuals *Halogeton glomeratus* and *Bassia hyssopifolia* germinated each spring but the seedling establishment period was critical in determining vegetation composition in each stand. Annuals were more responsive than perennials during the 2-month observation period when water was added to surface collected soil. Mesa dropseed, a perennial, had an abundant supply of stored seed in the soil surface ready to respond quickly to the extended moist condition provided by this experiment. This explains why this species is often observed in such great quantity following a period of above-average summer rainfall on the Deep Sand Range Site. In fair condition ranges it is by far the best represented species in soils as evidenced by germination.

Black grama could not be expected to increase quickly in abundance on fair or poor condition rangelands, even if all environmental conditions were ideal, since so few plants germinate and become established. Though abundant on the good condition range site with 27% of the plant composition, black grama made up less than 5% of the composition of plants emerging from the collected soil (Table 2). There were well over twice as many different plant species occurring in the field in all condition classes as emerged from the collected soils. This was due to perennial forb seeds either not being present in the collected soils or not germinating. Ten perennial species were represented in the field and only one perennial species emerged in the greenhouse. This could have been caused by germination inhibitors in the perennial plant seeds as speculated by Went (1949). *Aristida longiseta* was the only perennial grass species occurring in all field locations that did not emerge from collected soil. Grasses seemingly are better able to respond than forbs or shrubs when moisture is available for them to germinate.

The annual forbs, Russian thistle, *Tidestromia lanuginosa,* and *Chenopodium album,* were well accounted for by stored seed in all three condition classes. These species responded rapidly to favorable soil moisture. Annual forbs appear to be an important constituent of the Deep Sand Range Site either as growing plants or as stored seed, even in good condition range.

The woody plants which absorb much of the land manager's attention on this range site, broom snakeweed and mesquite, did not germinate from soil collected from the site. Perhaps these two species require a special set of environmental conditions for germination which were not met by the greenhouse study. A shortcoming of a study such as this is that only those seeds having completed any dormant period requirement and those without other inhibitors present were the ones to germinate. For this reason it is possible that seeds of some species were not observed in the collected soils.

Despite the large numbers of seeds occurring in the surface soil it appears that only a fraction of these are able to germinate at any given time. Went (1949) found more seeds were present in four desert soils than were observed to germinate after rain. In the present study, where moisture for germination was not limiting, the greatest number of plants emerging was 812 per m^2 from soil collected from the fair condition location.

The potential for plant populations to change as a result of environmental conditions permitting germination of buried seed is much less in good condition range than either fair or poor condition mainly because there are far fewer seeds available. One could speculate that an early result of grazing abuse on good condition range would be a quick reduction in primary productivity since there are few seeds of mid-successional species available at the outset of overgrazing to fill the niche as late successional grass species decline in abundance. Mesa dropseed appears to be the key mid-successional species in this study that fills a broad ecological niche from low good to low fair range condition. Reduced primary productivity would probably be less dramatic in fair condition because mesa dropseed appears ready to respond quickly to any variety of environmental influences than is the case for the Deep Sand Range Site in good condition.

Literature Cited

Duba, D. R., and B. E. Norton. 1977. Factors affecting distribution of *Halogeton glomeratus* and *Bassia hyssopifolia* on disturbed sites in northern Utah. Abstracts of Papers, Soc. for Range Management, Denver, Colo.

Dye, A. J. 1969. Germination potentials and accumulation of native plant seeds from southern New Mexico. MS Thesis, New Mexico State Universite, Las Cruces.

Gould, F. W. 1975. The grasses of Texas. Texas A&M Univ. Press. 653 p.

Kearney, T. H., and R. H. Peebles. 1964. Arizona flora. Univ. of California Press, Berkeley. 1085 p.

Major, J., and W. T. Pyott. 1966. Buried viable seeds in two California bunchgrass sites and their bearing on the definition of a flora. Vegetatio 13:253-278.

U.S. Dep. Agr. 1967. Range site technical descriptions and range condition guides. New Mexico, Soil Conservation Service, Albuquerque.

Valentine, K. A. 1970. Influence of grazing intensity on improvement of deteriorated black grama range. New Mexico State Univ. Agr. Exp. Sta. Bull. 553.

Went, F. W. 1949. Ecology of desert plants. II. The effect of rain and temperature on germination and growth. Ecology 30:1-13.