Problems in Artificial and Natural Revegetation of the Arid Shadscale Vegetation Zone of Utah and Nevada[1]

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Highlight

Vast areas of the arid shadscale zone have been rehabilitated through management, but direct plantings of both native and introduced species usually have failed. Future success will likely be with native plants, including shrubs, adapted to the particular site.

Attempts to revegetate the Great Basin sagebrush zone have been relatively successful, especially where annual precipitation exceeds 10 inches (Stoddart 1946; Plummer et al. 1955). Artificial seeding attempts in the drier shadscale zone generally have failed. Revegetation is needed to increase forage, to reduce erosion, and to control poisonous or noxious plants. This paper results from seeding trials and problems in revegetation of the arid shadscale zone.

Native vegetation.—The shadscale vegetation zone, also called salt desert shrub, covers over 40 million acres mainly in the southern and southwestern parts of the Intermountain region: Clements (1920); Graham (1937); Fautin (1946); Price et al. (1948); and Billings (1949). Isolated islands of the zone extend into eastern Oregon, southern Idaho, and southwestern Wyoming.

Included in the shadscale zone are a number of communities dominated by widely spaced shrubs. Shadscale (*Atriplex confertifolia* (Torr. & Frem.) S. Wats.) is the most extensive plant throughout the zone. Other common shrubs occurring in pure or mixed stands include: budsage (*Artemisia spinescens* D. C. Eaton), black sagebrush (*A. nova* A. Nels.), fourwing saltbush (*Altriplex canescens* (Pursh) Nutt.), Nuttall saltbush (*A. nuttallii* S. Wats.), mat saltbush (*A. corrugata* S. Wats.), small rabbitbrush (*Chrysothamnus stenophyllus* (A. Gray) Greene), winterfat (*Eurotia lanata* (Pursh) Moq.), spiny hopsage (*Grayia spinosa* (Hook.) Moq.), summer-cypress (*Kochia vestita* (S. Wats.) A. Nels.), and greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.), Low forms of big sagebrush (*Artemisia tridentata* Nutt.) are common on less xeric sites. Shrub ground cover is usually less than 10 percent. Interspaces are frequently bare or covered with a rock pavement.

Perennial grasses including Indian ricegrass (*Oryzopsis hymenoides* (Roem. & Schult.) Ricker), galleta (*Hilaria jamesii* (Torr.) Benth.), squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith), dropseed (*Sporobolus* sp.), needle-and-thread (*Stipa comata* Trin. & Rupr.), and blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud), are usually sparse; however, the first two occasionally occur in nearly pure stands. Native perennial forbs, such as globemallow, (*Sphaeralcea* sp.) and similar drought-enduring plants, occasionally occur in the various communities.

Native annuals such as eriogonum (*Eriogonum* sp.) are frequently abundant. On some areas, the native perennial vegetation has been replaced by halogeton (*Halogeton glomeratus* (M. Bieb.) C. A. Mey). Other important introduced annuals include cheatgrass (*Bromus tectorum* L.) and Russian-thistle (*Salsola kali* var. *tenufolia* Tausch).

Precipitation.—The mean precipitation regime varied considerably from western Nevada to eastern Utah. Billings (1949) using data from Sager (1932, 1941) reported that mean annual precipitation for the shadscale zone at 11 stations in western Nevada and eastern California ranged from 3.08 to 5.68 inches with an average of 4.15 inches and winter precipitation maximum as snow. In western Utah, Fautin (1946) reported that the mean annual precipitation for 6 shadscale stations averaged 7.95 inches. Precipitation was fairly well distributed throughout the year. In eastern Utah, Alter (1941) showed that the mean annual precipitation at 6 shadscale stations was 7.54 inches. Precipitation was relatively low in April, May, and June; however, over half of the mean total came in July, August, and September from convectional storms. Summer droughts are common and prolonged throughout the zone.

Soil. — Within the shadscale zone, soils are often heterogeneous even within short distances, but are generally of the Gray Desert group. Soils may or may not have a prominent hardpan; however, carbonates usually accumulate near the surface: Kearney et al. (1914); Shantz and Piemeisel (1940); and Stewart, Cottam, and Hutchings (1940). Parent material, degree of leaching, and drainage may account for the presence or absence of salt accumulation. Many vegetational types within the shadscale zone have been recognized and described with particular reference to their soil relation: Kearney et al. (1914); Shantz (1925); Shantz and Piemeisel (1940); Flowers (1934); Shreve (1942); Billings (1945, 1949); Fautin (1946); and Gates, Stoddart, and Cook (1956).

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Observations were made on one hundred and seven separate plantings within the shadscale zone in Utah and Nevada. Seed from 148 selected species of grasses, forbs, or shrubs were planted from 1937 to 1962. In addition, races or strains of promising species were planted. Summaries of major studies at selected locations in Utah and Nevada are shown in Table 1. Detailed information is presented for a few selected areas.

Two early plantings, one near the town of Cisco in eastern Utah and one in Wah Wah Valley in western Utah, maintained good stands of crested wheatgrass *(Agropyron desertorum* (Fisch. ex Link) Schult) for 15 years or more. The estimated mean annual precipitation on both areas was 6 to 7 inches.

Table 1. Selected plantings in the shadscale zone.

Location	Year of Planting	Size of Plots	No. of Species or Strains	Results	Status in 1962
Eastern Utah					
Cisco	1938	18 acres	1	Very good stand of crested wheatgrass persisted until 1955.	All dead
Cisco Thompson Castle Dale Buckhorn Flat	1950 also 1957 1958	small small small	82 17 22	Fair to good seedling stands of crested, fairway, intermediate, pubescent wheatgrass, Russian wildrye, and squirreltail on all sites. Poorer seedling stands of Nuttall saltbush, fourwing saltbush, and four species of dropseed.	All dead except scattered dropseed.
Central Utah					
Gunnison	1947 1950	small small	41 40	Various species produced good stands. Only crested wheatgrass, Russian wildrye, and bulbous bluegrass rated fair or better after 3 years.	Scattered plants
Gunnison	1947 1950	small small	18 28	Strain tests with sources of crested, fairway, and Siberian wheatgrass. Good seedling stands but high death loss from drought and rodents in 1958.	Fair to poor
Gunnison	1947 1950	small small	17 25	Strain tests with Indian ricegrass. Fair to poor seedling stands.	Scattered plants
Gunnison	1950	small	24	Strain tests with bearded and beardless wheatgrass. Fair to poor seedling stands.	Scattered plants
Gunnison	1950	small	12	Strain tests with squirreltail. Fair to good seedling stands.	Scattered plants
Gunnison	1947 1950	small small	9 12	Strain tests with fourwing saltbush. Poor to good seedling stands.	Scattered plants
Western Utah					
Wah Wah Valley	1939 1940	4 acres	10	Good seedling stands of crested wheatgrass, bearded wheatgrass, and bulbous bluegrass. Fair stand of crested wheatgrass and scattered salina wildrye plants.	Fair stand
Desert Expt. Range	1938 to 1940	small	105	Approximately 25 species produced fair seedling stands. Scattered plants of crested wheatgrass, spike dropseed, sand dropseed, and small rabbitbrush remain.	Scattered plants
Western Nevada					
Churchill Valley	1943 to 1956	small	77	Seven separate plantings. Poor to good seedling stands with grasses, forbs, and shrubs.	All dead
North Central Nevada					
Paradise Valley	1946 to 1953	small	32	Three separate plantings. Most species produced good seedling stands. All species except crested wheatgrass, Siberian wheatgrass, and Russian wildrye died. All species sharply reduced by drought in 1954 and 1955.	Scattered plants
Eastern Nevada					
Ely-McGill	1950 & 1953	small	25	Two separate plantings. Poor to good seedling stands gradually declined. Crested Wheatgrass and Russian wildrye best.	Scattered plants

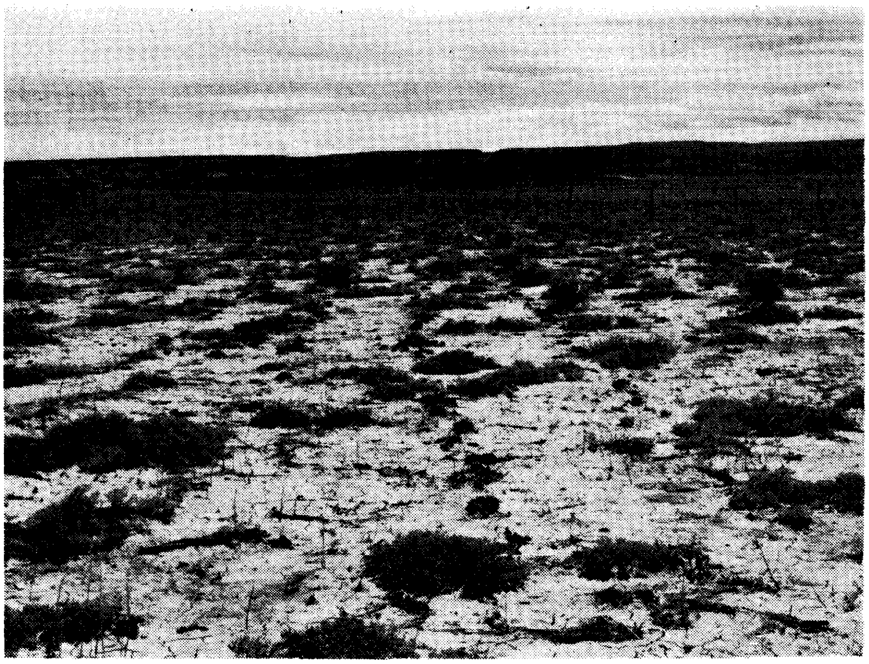

FIGURE 1. Remnants of dead crested wheatgrass plants in 1960 along rows planted near Cisco, Utah, in 1938.

The 1938 Cisco planting of 18 acres was done with a hand seeder in furrows made 36 inches apart with a farm layoff marker. The heavy clay loam derived chiefly from Mancos shale supported a rather sparse native cover of mat saltbush, Nuttall saltbush, squirreltail, and Indian ricegrass. The stand of native species was not eliminated by land treatment. An excellent grass stand was produced, and as late as 1950 forage production of crested wheatgrass was 350 pounds (dry weight) per acre. By July 1955, only rows of dead grass heaved out during the previous winter remained. Remnants of the heaved plants could still be seen in the summer of 1960 (Fig. 1). Horses had grazed the area lightly in 1954, but presumably drought of that year coupled with freezing and thawing in early 1955 eliminated this stand.

The Wah Wah Valley planting was made in the fall of 1939. Three seed mixtures were drilled without cultivation into a 4-acre native stand of winterfat and galleta. Crested wheatgrass, western wheatgrass (*A. smithii* Rydb.), beardless wheatgrass (*A. inerme* (Scribn. & Smith) Rydb.), bearded wheatgrass (*A. spicatum* (Pursh) Scribn. & Smith), tall oatgrass (*Arrhenatherum elatius* (L.) Presl.), salina wildrye (*Elymus salina* Jones), and bulbous bluegrass (*Poa bulbosa* L.) were drilled on a third of the area; fourwing saltbush, Nuttall saltbush, and winterfat were sown on another third; and a mixture of all these grasses and shrubs was sown on the remaining third. The area was replanted in the fall of 1940 because of drought.

Shrub seeds planted in both years failed to produce a single plant. Good seedling stands of crested wheatgrass, bearded wheatgrass, and bulbous bluegrass were present in the spring of 1941. By 1943, crested wheatgrass made up over 90 percent of the planted grasses. It survived and produced abundant seed in favorable years. Natural reproduction vegetated open areas and adjoining plots. Although most plants in the original drill rows died, reproduction maintained fair to good stands of crested wheatgrass (Fig. 2). In 1959, an average of 27 plants per 100 square feet was counted over the

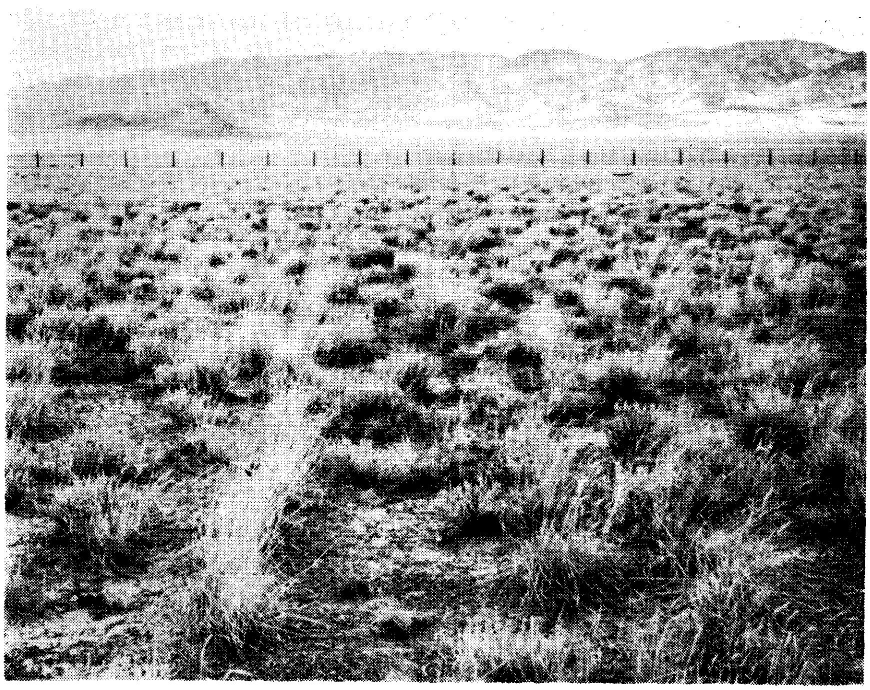

FIGURE 2. Crested wheatgrass planted in a native stand of winterfat in Wah Wah Valley in 1940 became established and produced seed in favorable years. Although most original plants died, natural reproduction maintained stands.

area. In June 1960, however, only 19 plants per 100 square feet were found. All plants of bearded wheatgrass died, but scattered plants of salina wildrye remained. This area has never been grazed by livestock.

Total forage yields have been similar, whether crested wheatgrass occurred in mixture with native winterfat or the latter grew in pure stands. Where the two species occurred together, both showed the effects of competition, especially in drought years.

Emergence, establishment, and mortality of eleven selected grasses including two strains of crested wheatgrass were followed on a 1946 planting in north-central Nevada. This study was near Paradise Valley, where the average annual precipitation was 8.6 inches. A clay loam 12 to 24 inches deep covered a heavy clay layer or pan. Budsage and fourwing saltbush, at densities of 2.5 and 4 plants per square foot, and a few severely grazed Indian ricegrass and squirreltail were eradicated prior to planting. The area was fenced to exclude rabbits and livestock.

By 1948, both strains of crested and Siberian wheatgrasses *(Agropyron sibiricum* (Willd.) Beauv.) had stands which rated "good." Intermediate wheatgrass *(A. intermedium* (Host) Beauv.), pubescent *(A. trichophorum* (Link) Richt.), bearded, tall *(A. elongatum* (Host) Beauv.), Russian wildrye, salina wildrye, and Indian ricegrass had stands which rated "fair." A local collection of squirreltail was the only species which rated "poor." All species except crested wheatgrass, Siberian wheatgrass, and Russian wildrye gradually declined. Crested wheatgrass, along with native shrub species, invaded all plots. By 1953, crested wheatgrass plants were of several size and age classes. All plants of intermediate wheatgrass, tall wheatgrass, and squirreltail and most of the salina wildrye and pubescent wheatgrass plants died prior to 1954.

All planted grasses except a few crested wheatgrass and Russian wildrye plants perished during the 1954-1955 drought, and the surviving plants had only 1 or 2 living culms within the original crown. Some of the native Indian ricegrass plants had survived the drought and were vigorous. Most of the native shrubs had survived the drought, but a few young budsage plants had died where competition from other shrubs or the planted grasses was severe.

In general established native shrubs in vigorous condition withstood the frequent droughts with minimum mortality. Native shrub seedlings generally were not highly drought resistant and often perished during the seedling year.

Natural native grasses withstood droughts better than introduced ones, but plant densities of the native species generally declined. During years with average or above-average moisture, stands of native species were usually restored by vegetal growth or from seed.

Plantings of drought-enduring grasses were disappointing. All plantings of blue grama and galleta failed to produce seedling stands. Good seedling stands of the needlegrasses and squirreltail gradually declined. Most species of dropseed failed, but a few poor initial stands of sand dropseed gradually improved through natural reproduction. Over sixty collections of strains of Indian ricegrass were tested. A few strains of this grass produced stands on some sites, but most strains had either failed to emerge or to surive.

A few plantings of perennial forbs produced good seedling stands, but mortality was usually very high. A few plants of native globemallow and penstemon were obtained from seeding. On several sites a small number of alfalfa *(Medicago sativa* L.) plants survived for several years before they were killed by drought, insects or rodents. The annual forbs, belvedere summer cypress *(Kochia scoparia* (L.) Schrad.) and fivehook bassia *(Bassia hyssopifolia* (Pall.) Kuntze), usually became established and produced viable seeds, but very few plants were present in subsequent years.

A similar response to artificial revegetation by use of grasses, shrubs and forbs was obtained at most study locations. Many species produced good seedling stands, but stands rapidly declined and most plants perished within a 10-year period. Results indicate that the arid climate was the most limiting factor encountered in artificial revegetation of the shadscale zone.

Discussion

Climate factors.—Prolonged or severe droughts in the shadscale zone inhibits seed germination. For example, at a study site in western Nevada, grass, forb, and shrub seeds planted in December 1954, and residual seeds of native annuals and perennials, remained in the soil during the subsequent winter, spring, and summer without germinating. Only 1.47 inches of precipitation was measured during the 13-month period from July 1954 to September 1955. After more than 8 months in the soil, 150 seeds each of fairway wheatgrass *(Agropyron cristatum* (L.) Gaertn.), crested wheatgrass, intermediate wheatgrass, and Russian wildrye were removed from the drill rows in August 1955. Seeds were not visibly damaged, and laboratory germination averaged 83, 80, 77, and 84 percent, respectively. Average germinations from the same lots that had been in storage were 79, 89, 96, and 93 percent, respectively. Seedling emergence in the drill rows was observed after a storm in

September 1955 and additional emergence was observed in the spring of 1956.

Further effects of climate were observed on a native stand of Indian ricegrass, where 96 percent of the plants died during the 1954-1955 drought. Original density was 72 plants per 100 square feet. The few surviving plants had only 1 or 2 living culms. Most of these culms produced good seeds in the summer of 1956. A few mature seeds were produced in 1954, but no viable seeds were found in 1955. Above-average available moisture followed this drought and seeds that had lain in the soil for years germinated. Many seedlings were growing on this site in the spring of 1956. By midsummer of 1956, the density averaged 49 vigorous seedlings per 100 square feet. As shown in Figure 3, seedling distribution was good; but a loose clustering, presumably around original parent plants, was common.

Small mammals and insects.—Rabbits and some rodents were often responsible for poor results from revegetation. The problem was magnified on small areas of cool-season grasses where green growth was produced in the fall and early spring. Larger areas such as the plantings at Cisco and Wah Wah Valley could better absorb the rodent population than small-plot areas and therefore were usually less damaged. Also, small rodents tended to concentrate inside enclosures where certain predators were less numerous.

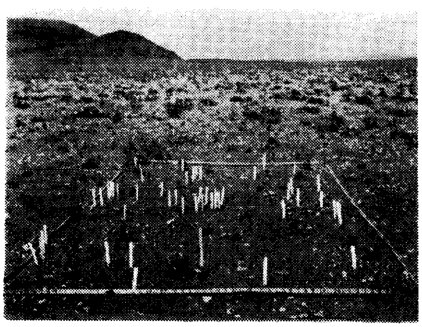

FIGURE 3. Markers show location of Indian ricegrass seedlings from residual seeds in the soil in 1956 after most parent plants perished in the 1954-1955 drought.

Established plants and particularly seedlings were frequently killed by close cropping or repeated heavy utilization. Plant crowns, also, were dug out and eaten in the early spring, late summer, or fall when green forage was sparse and especially during droughts when total forage was in short supply. Plants were also killed when the stem and roots were severed by pocket gophers or other animals as shown in Figure 4. Most shrub and forb seedlings were especially susceptible to damage by rodents because clipping of the hypocotyl or epicotyl usually resulted in death. Kangaroo rats and other rodents harvested large quantities of seeds and reduced the seeds available for natural revegetation.

In some years grasshoppers and crickets damaged established plants, killed seedlings, and reduced seed production. Harvester ants collected seeds and plant material, and areas occupied by ant hills produced no forage, Sharp and Barr (1960). Other insects in larval or adult stages contributed to the depleted condition within the zone by defoliation, stem boring, floral damage, and reduction of viable seeds, Piemeisel (1954).

Species variability.—Selection of adapted species was difficult. Seed of native grasses and shrubs collected on one site within the shadscale zone and planted on another site perished, while some reproduction from plants endemic to the site survived in some years. Variation of native species was often pronounced over relatively small distances. Ecotypic differences were observed in plant form, seed characteristics, seed dormancy, drought tolerance, salt tolerance, and similar traits.

Introduced grass and forb species exhibited variation in physiology. Dewey (1960) reported wide differences in salt tolerance in 25 strains representing 14 species of wheatgrasses. Results indicated that selection within species could be used to develop more salt tolerant strains.

Methods of planting.—Compe-

FIGURE 4. Shadscale plants were killed when pocket gophers severed the stem and roots. Since the remainder of the stem and larger roots could not be located, it was assumed they were dug out for food.

tition for available moisture by spring-growing annuals contributed to the early failure of plantings. During droughts, widely spaced shrubs made up most of the conspicuous vegetation. In years with above-average moisture, native and introduced annuals frequently were abundant.

Methods of planting designed to collect or conserve moisture around the seeds or in root zone produced the best seedling stands. Pits or furrows, water spreading, shading, or brush mulches were used. Furrows or pits to collect moisture were most successful on heavy soils with slow infiltration rates. Eradication of established shrub vegetation was a common practice. However, in years with better than average spring precipitation, seedling establishment was usually best near shrubs.

Many grasses, forbs, and shrubs germinated over a wide temperature range when moisture was adequate; however, optimum germination requirements varied with species or even strains of the same species. Late-fall plantings generally resulted in better seedling stands than early-fall or spring plantings. Low temperatures in late-fall usually prevented fall germination and winter cold reduced seed dormancy so that more seeds germinated in the spring when conditions were favorable. Early-fall plantings often germinated soon after planting and seedlings were subjected to low temperatures and winter drought. Frost damage to spring plantings was minimal; however, seed dormancy was a problem. Soil disturbances frequently resulted in rapid drying of the soil surface and late plantings shortened the spring growing period.

A dry soil surface caused by low humidity, high radiation, and moderate to strong winds generally necessitated deeper planting in the shadscale zone than in comparable soils in the sagebrush zone. Optimum planting depths also varied with species and size of seeds. The small seeds of dropseed, rabbitbrush, and sagebrush emerged best from shallow plantings and rarely from depths below 1 to 2 inches. In contrast, Indian ricegrass emerged from 4 inches. Although winterfat had relatively large seeds, optimum planting depth was about one-half inch.

Seed dormancy. — Seed dormancy was beneficial to survival of native plants. Fall and winter germinations were reduced and mortality from killing low temperatures and winter drought was minimized. Also, climatic conditions were not adequate for seed germination and plant establishment every year. Crocker and Barton (1957) stated that dormancy permits the extension of life of many seeds so that they are distributed in time as well as space.

Seed dormancy was characteristic of most native perennial species in the shadscale zone. A possible exception was winterfat. Freshly harvested seeds of this species germinated soon after fall planting when conditions were favorable. Normally germination occurred in late winter or early spring. On two separate occasions, vivipary was observed in the late fall on the current seed crop.

Several types of seed dormancy were recognized on plants native to this zone. New-seed dormancy, mechanical restraint, impermeable seed coats, and presence of inhibitors contributed to delayed germination in the native species. Dormancy of shadscale was decreased by storage, soaking the seeds in water at low temperatures, and moist cold stratification. Sixty-one percent of a seed lot that was in dry storage for 3 years germinated when seed coats were removed. Methods for increasing seed germination of grasses native in this zone were reported by Plummer and Frischknecht (1952), Rogler (1960), and Toole (1941).

In contrast, seed dormancy usually was minor or absent in most of the introduced cool-season grasses. Accumulated fall, winter, and current spring moisture usually was adequate for early spring seed germination and at least limited emergence of these cool-season grasses.

Natural revegetation.—Hutchings and Stewart (1953) reported that some ranges could be rehabilitated through improved grazing management. Rehabilitation through management provided for limiting forage use, whether use was by insects, small mammals, or livestock. Good management favored production of seeds of adapted plants distributed throughout the zone. Large seedling crops of native species were infrequent and occurred only once or twice in 10 or 15 years. Also, a favorable year for development of seedlings of one species was not necessarily favorable for seedlings of another species. Continued good management provided for production of seedlings and seedling establishment during years when seeds of adapted species were present and climatic conditions were favorable for seed germination and plant establishment.

Summary

Returns from revegetation of lands in the shadscale zone are low contrasted with those in the sagebrush zone. Many problems were encountered in the shadscale zone, but the arid climate appeared to be the major factor. Average annual precipitation ranged from 3 to more than 8 inches. Droughts were general throughout the zone. Low humidity, high evaporation, and high diurnal temperature fluctuations increased the severity of the climate. The heterogeneous soils in the shadscale zone usually contained more soluble

salts than comparable soils in the sagebrush zone.

Although vast areas have been rehabilitated through management, direct plantings of both introduced and native species usually failed. Good seedling stands usually were obtained with the wheatgrasses, but most plants perished during the first summer. A few plantings of the introduced crested wheatgrass, fairway wheatgrass, Siberian wheatgrass, and Russian wildrye maintained stands for 10 or more years.

Although resident shrubs and grasses dominated the various communities within the zone, good stands were difficult to obtain by artificial seeding. Low seed viability and seed dormancy were problems. Since seeds of many native and introduced species germinated at relatively low temperatures in late winter and early spring, frost damage occurred. Seedlings of native shrubs usually were not highly drought resistant and frequently perished during the first year. Site differences coupled with inherent differences between strains of a single species may have limited adaptability of these strains to specific localities. In addition, insects, rabbits, and rodents ravished the depleted land in some years. Success in this arid zone will likely depend on use of native plants adapted to the particular site. Future revegetation efforts should include the use of native shrubs which dominate the natural communities within this zone.

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