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Managing Intermountain Rangelands— Salt-Desert Shrub Ranges

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PREFACE

Managers and users of salt-desert shrub rangelands will find this publication to be a reference summary to aid in planning and decisionmaking. This is not a comprehensive literature review, but rather a distillation of some of the most useful information for on-the-ground management. Two manuals—Hutchings and Stewart (1953) and Hutchings (1954)—were based on the early years of grazing research at the USDA Forest Service's Desert Experimental Range (DER). They have been valuable guides for managers for three decades and, although out of print, are still useful. More recent experience at the DER, as well as much research information from other sources, warrants the broader updated summary in this publication.

Because much of the content herein derives from work at one location in the eastern part of the Great Basin—the DER—specific results may not all be directly applicable to other salt-desert shrub areas. Although general concepts, principles, and recommendations can be extended to distant salt-desert shrub lands, caution and professional judgment should be exercised in extrapolating the particulars.

RESEARCH SUMMARY

Salt-desert shrub rangelands cover some 40 million acres (16 million ha) of the Intermountain West. Much of this land was misused and damaged by unsound grazing practices in pioneer times and well into the 20th century.

Although productivity of the desert is low, the high quality of the range forage produced and the vastness of the area make the desert an important part of the regional resource base. Its principal value is in the annual harvest of feed by livestock. The ecosystem is fragile and easily disrupted by improper use, but under good management, deterioration can be reversed, condition can improve, and areas still in good condition can remain so under grazing use.

A grazing system compatible with other values of salt-desert shrub lands is one where grazing allotments are used as winter and early spring range, with each allotment grazed as several small units, each unit to be fully and properly harvested during one short period before the animals move on to the next one. With annual rotation of season of use of units and frequent years of rest from grazing on some of them, the harvest can be taken without detriment to soil stability, wildlife and game can thrive in their natural habitat, and the esthetic quality of the desert's vast emptiness can be enjoyed.

THE AUTHORS

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INTRODUCTION

Deserts of North America were described by Shreve (1942) in a comprehensive review where he recognized four major deserts: Great Basin, Mojave, Sonoran, and Chihuahuan (fig. 1). He characterized their vegetation as predominantly shrubby.

The Great Basin Desert is the northernmost of the four and includes all of the Great Basin physiographic province (Fenneman 1931) as well as adjacent parts of the Columbia and Colorado Plateaus. It extends into the Harney Basin of Oregon, the Snake River Plains of Idaho, the Red Desert of southwestern Wyoming, the western border of Colorado, northwestern New Mexico, and northern Arizona. The Great Basin Desert is largely above 4,000 ft (1 200 m), summers are warm and winters are cold, and annual precipitation is mostly between 4 and 10 inches (10 and 25 cm). However, the absence of a protracted dry season and the presence of moderate temperatures that result from higher latitudes and altitudes provide more favorable moisture conditions than the low precipitation indicates.

The two major plant communities of the Great Basin Desert are sagebrush-grass and salt-desert shrub, which are dominated by *Artemisia tridentata* and *Atriplex confertifolia*, respectively. Sagebrush-grass vegetation, which occupies some 100 million acres (40 million ha) of western rangeland, has been treated recently in a companion publication (Blaisdell and others 1982) and will not be considered further herein. Although estimates of the area dominated by salt-desert shrub vegetation vary considerably (Branson and others 1967; Hutchings and Stewart 1953), 40 million acres (16 million ha) is a reasonable figure for this important range ecosystem (Holmgren and Hutchings 1972). General location of this vegetation type is shown in figure 2.

Salt-desert shrub vegetation occurs mostly in two kinds of situations that promote soil salinity, alkalinity, or both. These are either at the bottom of drainages in enclosed basins (bolsons) or where marine shales outcrop (West 1982a). The bolsons of the Great Basin, where salts and fine-textured fluvials or lacustrine materials have not been able to escape to the oceans, constitute the major area of salt-desert shrubs. The sediments from former seas outcropping in dry climates as shales of Cretaceous age have also developed halomorphic soils. Part of the Snake River Plains in southwestern Idaho and the Big Horn Basin and Red Desert of Wyoming are examples. Soils derived from these formations are so salty and fine textured that they create salt-desert shrub habitat in a climate that would normally produce grassland. On the other hand, Billings (1949) described a shadscale community in western Nevada as occupying not only the dry lake sediments with mild concentrations of subsoil salt, but also dry salt-free residual and fan soils where annual precipitation is under 6 inches (15 cm). Apparently, shadscale and other salt-desert shrubs may be indicators of climatically dry areas as well as physiologically dry soils.

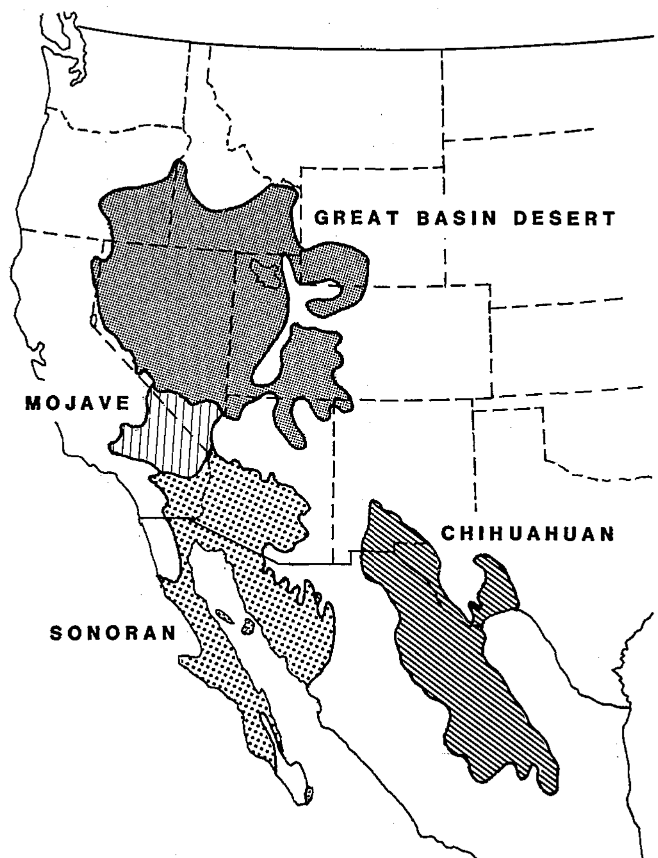


Figure 1.—Deserts of North America (after Shreve 1942).

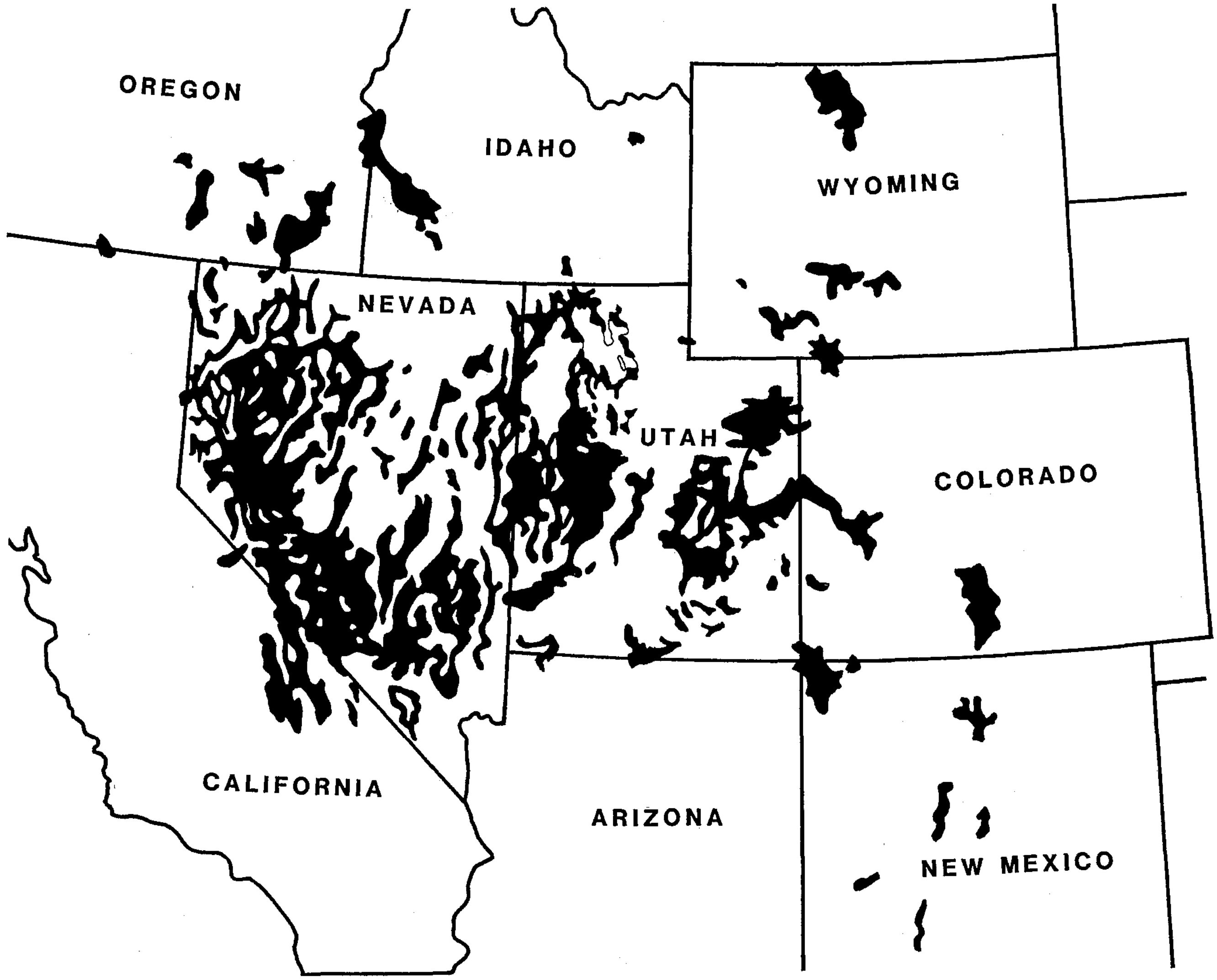


Figure 2.—Distribution of salt-desert shrub vegetation. (Compiled from maps of Kuchler 1964, Billings 1949, Smith ca. 1961, and Nevada Resource Action Council, n.d.).

The Resource

Vegetation.—Vegetation of salt-desert shrub ranges is characteristically sparse. The mosaic of plant communities is largely dominated by shrubs and half-shrubs of the family Chenopodiaceae. Some of the most important species are shadscale (*Atriplex confertifolia*), Gardner saltbush (*Atriplex gardneri*), mat saltbush (*Atriplex corrugata*), fourwing saltbush (*Atriplex canescens*), Castle Valley clover (*Atriplex cuneata*), greasewood (*Sarcobatus vermiculatus*), winterfat (*Ceratoides lanata*), and spiny hopsage (*Grayia spinosa*). Several shrubs of the family Compositae are also prominent members of salt-desert shrub vegetation including budsage (*Artemisia spinescens*), black sagebrush (*Artemisia nova*), and low rabbitbrush (*Chrysothamnus viscidiflorus* ssp. *stenophyllus*).

Associated with the shrubs are such cool-season grasses as Indian ricegrass (*Oryzopsis hymenoides*), squirreltail (*Sitanion hystrix*), and Sandberg bluegrass (*Poa sandbergii*). Important warm-season grasses are galleta (*Hilaria jamesii*), alkali sacaton (*Sporobolus airoides*), sand dropseed (*Sporobolus cryptandrus*), and blue grama (*Bouteloua gracilis*). A number of annuals also grow in association with the shrubs and grasses of the salt desert. Usually they are rare, being confined to sites of recent disturbance such as road construction or overgrazing. Kind of annuals, density, and yield are extremely variable from year to year and from place to place. In some years scarcely any annuals emerge, even where competition from perennial species is lacking.

Native annuals seldom comprise more than a small fraction of the total cover, but three exotic species produce abundantly on poor condition range when the amount and timing of precipitation are favorable. These are cheatgrass (*Bromus tectorum*), a winter annual, and two summer annuals belonging to the chenopod family, Russian thistle (*Salsola kali*) and halogeton (*Halogeton glomeratus*). Halogeton is poisonous to livestock, but cheatgrass and Russian thistle are both palatable and nutritious. However, as annuals they are an undependable source of forage.

Livestock range.—As livestock range, salt-desert shrub is unique among American grazing lands. Because of the arid climate, herbage yields and grazing capacities are low. About 1.5 to 3 acres (0.6 to 1.2 ha) are needed to support a sheep for a month, and between 10 and 20 acres (4 and 8 ha) or more are required for a cow (Holmgren and Hutchings 1972). The salt desert is mainly a winter range used for maintenance of breeding or gestating livestock; consequently, nutritional requirements are relatively low. The living twigs of dormant shrubs, some with persistent seeds, make this range more nearly adequate for animal maintenance (Cook and others 1954) than other cold-weather ranges where the aerial plant parts are dead.

Wildlife habitat.—Salt-desert shrub communities serve as habitat for wildlife that range in size from insects and small mammals to birds and large herbivores. Although salt-desert communities are relatively simple in terms of structure and species diversity, they support a wide variety of animal species. In Utah, for example, 59 percent of the mammals, 28 percent of the birds, and 38 percent of the reptiles and amphibians occur in the salt desert (McArthur and others 1978).

In addition to an abundance of songbirds, rats, mice, lizards, snakes, and insects, several species are important as game in the salt desert: the mourning dove (*Zenaidura macroura*), jackrabbits (*Lepus californica*), cottontails (*Sylvilagus auduboni*), pronghorn antelope (*Antilocapra americana*), and mule deer (*Odocoileus hemionus*) (Hancock 1966; Wallmo 1975). Other small game such as chukar partridge (*Alectoris chukar*) and sage grouse (*Centrocercus urophasianus*) are sometimes present in the periphery of salt-desert communities. The pronghorn is more common than deer in salt-desert shrub vegetation; however, both are highly mobile and make much use of associated habitats, especially sagebrush-grass.

A number of predators are common in the salt desert. These include the coyote (*Canis latrans*), bobcat (*Lynx rufus*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), great horned owl (*Bubo virginianus*), bald (*Haliaeetus leucocephalus*) and golden (*Aquila chrysaetos*) eagles, Swainson's (*Buteo swainsoni*) and redtailed (*Buteo jamaicensis*) hawks, and prairie falcon (*Falco mexicanus*) (Fautin 1946; Hancock 1966).

Because of its size and easy accessibility, salt-desert shrub range constitutes an important resource for production of livestock and wildlife; open space, scenic beauty, and a variety of recreational activities; and a resource reserve to be maintained and improved as an important national asset to satisfy some presently unforeseeable needs (Blaisdell and others 1970).

Problems

Salt-desert shrublands, like other western ranges, have been damaged by livestock grazing. According to estimates by Clapp (1936), western range depletion was more than 50 percent as measured by reduction in grazing capacity, with salt-desert shrub ranges at 70 percent. The original grazing capacity of salt-desert shrub range had changed from about 5 acres (2 ha) per animal unit month (AUM) to a requirement of 18 acres (7.2 ha) (McArdle and others 1936). Although some improvement since the 1940's is indicated by recent estimates (USDA Forest Service 1981), direct comparisons with the earlier data are not possible because of differences in plant community definitions.

The naturally sparse plant cover along with fine-grained saline soils have made salt-desert shrub ranges especially vulnerable to water and wind erosion. Although not all salt-desert areas are high sediment producers, some are among the most severely eroding localities in the Intermountain region. A major concern is with sediment and, consequently, salt eroding into the Colorado River. Frail lands in the upper Colorado River basin, largely shale badlands in the salt-desert shrub areas, yield about 85 percent of the sediment but only 1 percent of the water (West 1982). Wind is also a serious cause of erosion, especially where natural vegetation has been depleted by grazing or other disturbances. Microphytic crusts of the interspaces help to stabilize the soils, and the blue-green algal component is a major fixer of nitrogen. However, disturbance by livestock trampling weakens this crust and greatly increases the susceptibility of soil particles to wind and water erosion.

Besides livestock grazing, such disturbances as construction of energy or transportation corridors, military operations, surface mining, and recreation have created unsatisfactory vegetation conditions. Because depleted salt-desert shrub ranges are slow to improve under either good management or complete protection, direct revegetation is often desirable and necessary. However, the harsh environment usually makes successful revegetation difficult (Bleak and others 1965; Van Epps and McKell 1980). Special practices such as transplanting, watering, shading, soil additives, or extremely careful selection of plant materials may be necessary.

Other problems are related to management of the unique flora and fauna. A number of endemic plants are classed as threatened or endangered and must be given adequate protection. Although wildlife species are limited and their populations are low, a growing concern exists for better wildlife management, especially for recreational values. Most forms of recreation on salt-desert shrub ranges employ off-road vehicles to reach scenic, hunting, camping, and rock-collection areas; and the wheels can destroy vegetation, including microphytic crusts, and cause accelerated wind and water erosion (West 1982).

An adequate classification system has not been developed for salt-desert vegetation or sites; consequently, range condition and trend cannot be easily evaluated and management practices cannot be readily extrapolated. Although considerable attention has been given to the effect of grazing on salt-desert shrub ranges (Holmgren 1973), complete grazing systems have not been synthesized and tested nor have effects of kind of livestock and their relations with wildlife been adequately determined.

Management of salt-desert shrub ranges is further complicated by pests such as insects and diseases that damage the vegetation, rodents and rabbits that use forage and provide food for predators, and introduced annual weeds such as Russian thistle and cheatgrass that compete with native species, or halogeton that can be extremely toxic to sheep (Hutchings 1966b). Predators such as bobcats and coyotes can also have serious impacts on populations of antelope or domestic sheep. Much information is needed on what is normal and what needs management attention.

IMPORTANT SPECIES OF THE SALT-DESERT SHRUB ECOSYSTEM

Ecosystem is a term proposed by Tansley (1935) to include living organisms of a community and the associated nonliving environment. Although the salt-desert shrub ecosystem has numerous components, attention here is focused on vegetation, climate, and soils.

Shrubby Chenopods

Commonly known as saltbushes, shrubby chenopods are the principal vegetal component of salt-desert shrub ranges. They provide livestock forage, wildlife habitat, and ground cover to stabilize dry saline/alkaline soils where few other plants are adapted (Blauer and others 1976).

Various species or ecotypes show tremendous differences in tolerance to salinity and have a remarkable ability to persist under wide climatic variations (McArthur and others 1978). All saltbushes bear a one-celled fruit known as a utricle, within which is a single seed. The utricle wall may be thin and easily removed from the seed, as with winterfat, or hard, as with shadscale. Unless seed coats are restrictive, germination takes place quickly in a favorable moisture and temperature environment. Utricles that have indurated walls may lie a year or more in the ground before germination. This attribute seems to promote survival of the species because it insures a seed supply when favorable conditions occur. Most shrubby chenopods are highly nutritious with a higher protein content than many other plants. Several species have persistent leaves that remain green and palatable throughout the winter. Blauer and others (1976) and McArthur and others (1978) have developed descriptions of the major species of shrubby chenopods. Summaries emphasizing characteristics and distribution follow:

Atriplex canescens **(fourwing saltbush).**—This large shrub ranges from 1.65 to 6.6 ft (0.5 to 2 m) tall (fig. 3). It branches freely from the base. Both the young twigs and leaves are gray green because of the white , scurfy vestiture. The linear to oblanceolate evergreen leaves are 0.4 to 1.6 inches (1 to 4 cm) long and 0.08 to 0.24 inch (2 to 6 mm) wide. This saltbush is usually dioecious, but a small percentage of monoecious plants is common in many populations. Pistillate flowers are inconspicuous with no parts other than a pistil enclosed by a pair of small bracts that are united along their edges to form winglike expansions. In addition, each bract of the pair has a wing down its middle causing the somewhat-variable fourwing characteristic of the utricle. Yellow to red staminate (male) flowers are borne in glomerules 0.08 to 0.12 inch (2 to 3 mm) wide. Blooming of fourwing varies from May to August depending on latitude and elevation. Utricles mature 14 to 16 weeks after flowering.

This species, one of the most widespread of western shrubs, grows on a wide variety of soil types from the Great Plains to the coast ranges and from Canada to Mexico at elevations from below sea level to about 8,000 ft (2 440 m). Fourwing is frequently associated with greasewood, shadscale, basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), winterfat, and a number of grasses. Because of its abundance, evergreen habit, palatability, nutritive value, and rapid growth rate, fourwing is one of the most valuable forage shrubs in arid rangelands. It has remarkable ability to tolerate twig removal by grazing by regenerating new twigs on old wood within the crown. Also, it is important in the rehabilitation of western rangelands because it can be easily propagated by direct seeding, transplanting, or using stem cuttings.

Atriplex confertifolia **(shadscale saltbush).**—Shadscale is a compact, spinescent shrub growing typically in dense clumps from 8 to 32 inches (2 to 8 dm) high and 12 to 68 inches (3 to 17 dm) wide (fig. 4). The rigid branches are scurfy when young, but become smooth and spiny with age. The gray-scurfy leaves are nearly circular to elliptic, oval, or oblong, 0.36 to 1 inch (9 to 25 mm) long and 0.16 to 0.8 inch (4 to 20 mm) wide. Flowers of shadscale are similar to those of fourwing except in the nature of the bracts enclosing the seed. The bracts of shadscale are foliose, 0.20 to 0.48 inch (5 to 12 mm) long, broadly ovate to round, united at the base, with free, somewhat spreading margins. Blooming varies from late March in the southern part of its range to about mid-June in the north. Utricles mature about 15 weeks after blooming. They are fairly persistent through the winter and are sought out by grazing animals.

Shadscale is widely distributed from Canada to Mexico at elevations from 1,500 to 7,000 ft (460 to 2 135 m). It occurs most often on fine-textured, alkaline soils, but also on coarser soils containing considerable sand. It occurs in nearly pure stands and in mixtures with winterfat, budsage, black sagebrush, low rabbitbrush, hopsage, greasewood, gray molly (*Kochia americana* ssp. *vestita*), other saltbushes, and several species of grass. A number of ecotypes grow on a wide range of sites including highly alkaline soils. Shadscale has a short life span and is often killed by droughts.

Shadscale twigs become rigid and spiny as they mature, and during the winter some forms are nearly leafless. The spiny characteristic protects the plant from heavy grazing damage. Nevertheless, it provides palatable and nutritious forage to a wide variety of livestock and other animals. It is an increaser on many areas and often becomes dominant as more palatable species are killed by grazing.

Atriplex corrugata **(mat saltbush).**—This is a low shrub that forms dense, prostrate mats from adventitious rooting (fig. 5). The bark is soft, spongy, and white. The evergreen, sessile leaves are opposite on the lower part of the stems and alternate above. They are densely scurfy and from 0.28 to 0.72 inch (7 to 18 mm) long. The plants are dioecious or rarely monoecious. Yellow to light brown staminate flowers are born in glomerules 0.12 to 0.24 inch (3 to 6 mm) wide on nearly naked spikes. The pairs of fruiting bracts that enclose the pistils of the female flowers are sessile, 0.12 to 0.20 inch (3 to 5 mm) long, 0.16 to 0.24 inch (4 to 6 mm) wide, and united along most of their length. The plant flowers from April to June. Fruit ripens 5 to 6 weeks later.

Mat saltbush occurs mainly on soils derived from mancos shale in eastern Utah, western Colorado, and northwestern New Mexico at elevations from 4,000 to 7,000 ft (1 220 to 2 130 m). It is probably the most salt-tolerant shrub in the genus, but also grows where salt concentrations are moderate in association with such shrubs as winterfat, shadscale, greasewood, budsage, and gray molly. It is more important for soil stabilization than for forage.

Atriplex cuneata **(Castle Valley clover).**—The plant is a low shrub with a fairly prostrate, much-branched base and erect branches (fig. 5). It varies in height from 0.3 to 1.5 ft (10 to 45 cm) and has light gray-green, spatulate to broadly elliptic evergreen leaves 0.8 to 2.4 inches (2 to 6 cm) long and 0.2 to 1.0 inch (0.5 to 2.5 cm) wide. This species is usually dioecious. Yellow to brown staminate flowers are borne in glomerules arranged in panicles, and pistillate flowers are in axillary clusters with pistils enclosed by wingless bracts. At maturity, the bracts are 0.2 to 0.45 inch (5 to 9 mm) wide, irregularly toothed along their margins with flattened, crestlike tuberules on their side. Blooming occurs from mid-April to July, depending on elevation and climate. Seed ripens about 7 weeks later.

This shrub occurs in highly alkaline soils in eastern Utah, southwestern Colorado, and northern New Mexico. Often it is the dominant plant or is codominant with shadscale or mat saltbush. It remains green and succulent throughout the winter and is nutritious and highly palatable to all grazing animals.

Atriplex gardneri **(Gardner saltbush).**—A low half-shrub, woody at the base but herbaceous above (fig. 6). Gardner saltbush has lightly scurfy leaves that are evergreen, spatulate to obovate, 0.6 to 2.2 inches (15 to 55 mm) long and 0.2 to 0.5 inch (5 to 12 mm) wide. The spineless, decumbent branches often produce adventitious roots where they contact the soil. Annual flower stalks arise from the woody portion of the plant. Most plants are dioecious. The brown staminate flowers are borne in glomerules 0.12 to 0.20 inch (3 to 5 mm) wide on nearly naked, terminal panicles, whereas pistillate flowers are borne on leafy spikes. Gardner saltbush flowers from mid-May to early July and intermittently following heavy rains. Fruit ripens about 7 weeks after the flowering.

Gardner saltbush is much more restricted in its habitat than are fourwing and shadscale. It is most abundant on badland clay soils with a fairly high concentration of soluble salts. It is found mostly in Wyoming and Montana, but also in Colorado, Utah, and southern Idaho. This species is important as browse for game and livestock and for soil stabilization. It tolerates severe use, especially during winter.

Atriplex tridentata **(saltsage).**—According to Stutz and others (1979), saltsage has several characteristics that distinguish it from other species of *Atriplex*. It is upright in habit, with numerous linear leaves borne on coarse, herbaceous, greenish-gray stems (fig. 7). It is one of the latest of the *Atriplex* species to flower—usually during June or early July. Consequently, its fruits mature late and may be harvested as late as midwinter.

Although saltsage can sometimes be confused with Gardner saltbush, they differ in several features. Gardner saltbush is usually prostrate with only a few upright, sparsely-leafed flowering stalks, mostly less than 12 inches (30 cm), whereas saltsage is an erect plant, with many leaves on the numerous, tall flower stalks. Most Gardner saltbush leaves are borne close to the ground, but most saltsage leaves are high above the ground and crowded along the stems. Leaves of Gardner saltbush are spatulate and much shorter and broader than the linear leaves of saltsage. Saltsage is a vigorous root-sprouter, whereas Gardner saltbush rarely shows this characteristic. Gardner saltbush flowers and produces fruit much earlier than saltsage. As for geographical distribution, Gardner saltbush is abundant in Montana and Wyoming; saltsage is confined mostly to the Lake Bonneville basin in Utah and the borders of neighboring states.

Ceratoides lanata **(winterfat).**—This erect or spreading halfshrub has a wide variation in stature from less than 16 inches (40 cm) to as much as 5 ft (1.5 m) (fig. 8). Dwarf forms are herbaceous above a woody base, whereas taller forms tend to be woody throughout. Branches and leaves are covered with a dense coating of stellate and simple hairs that are white when young but become rust-colored with age. Leaves are alternate, linear, 0.2 to 2 inches (5 to 50 mm) long, with entire, strongly revolute margins. Winterfat can be either monoecious or dioecious. Flowers are borne in dense paniculate clusters along the upper part of the branches. Pistillate flowers are below the staminate on monoecious plants. Staminate flowers lack bracts and petals, being comprised of four sepals and four stamen borne opposite the sepals. Pistillate flowers lack both sepals and petals. Pistils are enclosed by a pair of bracts that are united more than half their length. The bracts are covered by long, silky hairs that distinguish winterfat from the saltbushes. Winterfat blooms between May and August; fruit ripens from September to November. Seed production of winterfat is highly dependent upon precipitation, and is much less consistent than that of the saltbushes (*Atriplex* spp).

Winterfat approximates fourwing saltbush in distribution, ranging from Canada through the Great Basin and Rocky Mountain States to Mexico, and from California and Washington eastward to North Dakota and Texas. It is most abundant on lower foothills, plains, and valleys with dry, subalkaline soils. It often occurs as pure stands over wide areas. It is a palatable and nutritious browse for both livestock and big game. However, abusive grazing has reduced or eliminated winterfat on some areas even though it is fairly resistent to such use.

Grayia spinosa **(spiny hopsage).**—This spinescent shrub is erect, diffusely branched, and from 12 to 48 inches (3 to 12 dm) in height (fig. 9). The deciduous, somewhat fleshy leaves are oblanceolate, 0.16 to 1.7 inches (0.4 to 4.3 cm) long, 0.08 to 0.5 inch (2 to 13 mm) wide. The small, greenish, unisexual flowers usually occur on separate plants, but a few may be monoecious.

Staminate flowers are clustered in glomerules in the axils of leaves, whereas pistillate flowers are mostly in dense terminal spikes. Fruits are enclosed by pairs of rounded, flat-winged, sessile bracts, 0.2 to 0.5 inch (5 to 12 mm) wide, and often tinged with red. Flowering period is from April to June, and seeds mature by mid-July. Leaves usually fall shortly after seed maturity.

Spiny hopsage is found on a wide range of soils from California to eastern Oregon and Washington, and east to New Mexico, Colorado, and Wyoming. Soils are typically high in calcium and strongly basic, but may also be neutral. It is a valuable forage plant in areas where it is abundant, especially in the spring when in full leaf.

Kochia americana **ssp.** *vestita* **(gray molly).**—A small halfshrub up to 20 inches (5 dm) tall (fig. 10), gray molly's numerous, erect branches and leaves are covered with long, silky hairs. The linear, fleshy, somewhat terete leaves are 0.2 to 1.2 inches (5 to 30 mm) long. Perfect or pistillate flowers are borne singly or in small clusters in the axils of leaves. The fruit is largely concealed in a persistent calyx, which develops fanlike, papery wings up to 0.12 inch (3 mm) long. Blooming occurs between June and August, depending on precipitation.

Gray molly usually occurs on saline or alkaline clay soil on plains and foothills at elevations from 4,500 to 6,000 ft (1 370 to 1 830 m). It ranges from southern Montana, west to Oregon, and south to New Mexico and Arizona. A fair forage for livestock, the dry, dead twigs are taken by both sheep and cattle in winter.

Sarcobatus vermiculatus **(black greasewood).**—This is an erect, spiny-branched shrub up to 10 ft (3 m) tall (fig. 11). Deciduous, bright green leaves are 0.4 to 1.6 inches (1 to 4 cm) long, narrowly linear, and semiterete. It is usually monoecious with staminate flowers borne in catkinlike spikes 0.2 to 1.2 inches (0.5 to 3 cm) long. Flowers lack both sepals and petals and consist of only two or three stamens borne under long-stalked, shieldlike bracts. Pistillate flowers are borne below the staminate catkin in the axils of reduced leaflike bracts. Flowers bloom from May to July. Pistils are enclosed by cuplike perianths, the lower parts of which become adherent to the ovaries, and the upper parts expand into broad, membranous wings of the fruit. Seed production is abundant in occasional years.

Greasewood grows on a wide range of soils but is most characteristic on rather heavy, alkaline areas where flood waters collect or where the water table is high at least part of the year. It ranges from Canada to Texas and California and from the Dakotas, Colorado, and New Mexico west to Oregon, Washington, and California. Greasewood can be found in nearly pure stands, but in less saline areas it may be associated with such shrubs as shadscale, Gardner saltbush, rabbitbrush, basin big sagebrush, budsage, spiny hopsage, and winterfat. It is browsed by cattle when green, but contains soluble oxalates that may cause poisoning and death if hungry animals consume large amounts in a short time.

Shrubby Composites

Several shrubs belonging to the family Asteraceae are important components of many salt-desert shrub communities or grow in close association with them. These include budsage, black sagebrush, basin big sagebrush, and low rabbitbrush. Descriptions of these species emphasizing characteristics and distribution were developed by McArthur and others (1979) and are summarized in the following paragraphs.

Artemisia spinescens **(budsage).**—A low, spinescent, aromatic shrub 4 to 20 inches (1 to 5 dm) high (fig. 12), budsage is profusely branched from the base and has white-tomentose pubescence on young twigs and leaves. Leaves are small, mostly 0.8 inch (2 cm) or less in length including the petiole. Leaves are three to five palmately parted, with the divisions again divided into three linear-spatulate lobes. Unlike most species of *Artemisia*, budsage is deciduous, with leaves falling by midsummer. Early in the spring when budsage first shows signs of breaking dormancy, the bark from last season can easily be pulled off. In this condition, known as "slipping," budsage is extremely palatable to game and livestock. New bright-green leaves are produced as early as February or March.

Budsage bears small flower heads 0.12 to 0.2 inch (3 to 5 mm) long in glomerate racemes of one to three heads in leaf axils of the flower branches. Each head contains 2 to 6 fertile, pistillate ray flowers and 5 to 13 perfect but sterile flowers with abortive ovaries. The loose flower heads are held together by long, matted hairs that cover the corolla and especially the achenes. The heads fall from the plant intact, without breaking apart to release the seed. Seeds sometimes germinate while still in the head. Good seed production occurs infrequently because flowers bloom so early in the spring that developing embryos are often frozen. However, abundant reproduction occurs in years of plentiful seed and favorable moisture.

Budsage is found on dry, often saline plains and hills from southwestern Montana, southeastern Idaho, and eastern Oregon, southwest to California, New Mexico, Arizona, and Colorado. It is often associated with shadscale, black greasewood, and other salt-tolerant shrubs, and in some areas with black sagebrush and basin big sagebrush. It provides palatable, nutritious forage for upland birds, big game, and livestock.

Artemisia nova **(black sagebrush).**—This sagebrush is a small spreading aromatic shrub 6 to 18 inches (1.5 to 4.5 dm) tall with dull, grayish-tomentose vestiture that causes some races of it to appear darker than other sagebrushes (fig. 13). Numerous, erect branches arise from a spreading base, but black sagebrush has not been observed to layer or sprout. Typical leaves are evergreen, cuneate, viscid from a glandular pubescence, 0.2 to 0.8 inch (0.5 to 2 cm) long, 0.08 to 0.32 inch (2 to 8 mm) wide, and three-toothed at the apex. The uppermost leaves, particularly on the flowering stems, may be entire. Flower heads are grouped into tall, narrow, spikelike panicles that extend above the herbage. The inflorescence stalks are red-brown and persistent. Heads usually contain from three to five disc flowers with corollas 0.07 to 0.12 inch (1.8 to 3 mm) long. The 8 to 12 involucral bracts are greenish yellow and nearly glabrous. Flowering occurs from August to mid-September, and seeds mature in October and November.

Black sagebrush is most abundant at elevations from 5,000 to 8,000 ft (1 500 to 2 400 m) on dry, shallow, stony soils often underlain by bedrock or hardpan. In the Great Basin, this species is more closely associated with salt-desert habitats than any other *Artemisia* with the exception of budsage. It is highly palatable to sheep, antelope, and sage grouse.

Artemisia tridentata **ssp.** *tridentata* **(basin big sagebrush)**.—This sagebrush is an erect, heavily branched, unevenly-topped shrub with trunklike, main stems (fig. 14). Shrubs range between 1.5 and 6.6 ft (0.5 and 2 m) in height. However, some forms may reach 15 ft (4.5 m) in nondesert habitats. The evergreen, vegetative leaves are narrowly lanceolate, up to 2 inches (5 cm) long by 0.2 inch (5 mm) wide, and typically three-toothed at the apex. The leaves of the flowering stems, however, gradually become smaller and may be linear or oblanceolate and entire. The gray-canescent foliage possesses a strongly pungent, aromatic odor. Flowering stems arise throughout the uneven crown and bear numerous flower heads in erect, leafy panicles. The heads contain three to six small, yellowish or brownish, trumpet-shaped, perfect disc flowers. The narrowly campanulate involucre consists of canescent bracts 0.12 to 0.16 inch (3 to 4 mm) long and about 0.08 inch (2 mm) wide that form four to five overlapping series around each head. The outermost bracts are less than a fourth as long as the innermost bracts. Flowering occurs from late August to October. Seed matures, depending on site, from October to November.

This subspecies has generally been regarded as intolerant of alkali, but there are ecotypes that grow in association with alkali-tolerant plants such as black greasewood and shadscale. Some forms or races of basin big sagebrush are palatable to livestock as well as deer and antelope. It is generally considered one of the most nutritious shrubs on winter game and livestock ranges. Despite some evidence that digestibility of big sagebrush was suppressed by high content of volatile oils (Nagy and others 1964), Welch and Pederson (1981) found no relation between total volatile oil content and digestibility.

Chrysothamnus viscidiflorus **sspp.** *axillaris* and *puberulus* and *C. greenei* **(low rabbitbrushes)**.—These small, glabrous shrubs are up to 12 inches (3 dm) high with white bark (fig. 15). Leaves are linear-filiform, often twisted, viscidulous, 0.08 inch (2 mm) or less wide, 0.4 to 1.2 inches (1 to 3 cm) long. Flower heads contain perfect, fertile, yellow disc flowers each arranged in compact terminal cymes. Fairly common on Great Basin desert ranges, these shrubs are also found in sagebrush communities on the poorer soils and disturbed areas. They associate with such salt-desert shrubs as winterfat, shadscale, fourwing saltbush, and black sagebrush. Low rabbitbrushes increase when more palatable species are destroyed by improper use.

Grasses

Both warm-season and cool-season grasses are associated with various plant communities of salt-desert shrub ranges. The following descriptions, characteristics, and distributions of the grasses are largely from Dayton and others (1937) and Hitchcock and Chase (1950).

Hilaria jamesii **(galleta)**.—An erect, open sod-forming, perennial grass, galleta has a decumbent base and tough, scaly rhizomes (fig. 16). Culms are glabrous, but the nodes are villous. Spikes are distinctive, resembling those of wildrye or wheatgrass, but are readily distinguishable by their broad, papery glumes. The spikelets are borne in close stemless clusters alternately arranged on a zigzag rachis. Each cluster has three spikelets, with only the center one producing seeds. The entire cluster falls at maturity leaving the rachis naked. Leaf blades are rigid, soon involute, mostly 0.8 to 2 inches (2 to 5 cm) long and 0.08 to 0.16 inch (2 to 4 mm) wide. It grows on mesas, plains, and deserts from Wyoming, Utah, and Nevada south to southern California, Arizona, and New Mexico. Galleta is most palatable when green and succulent, but often receives considerably use in winter when the leaves are cured. Because of its tough, woody rhizomes, this plant can reproduce itself despite pressures from grazing or drought. It is a warm-season grower and will not go into its reproductive phase without adequate summer precipitation.

Sporobolus cryptandrus **(sand dropseed)**.—Grasses of the genus *Sporobolus*, have one-flowered spikelets, the rachilla disarticulating above the glumes, which are one-nerved and usually unequal. Lemmas are membranaceous, one-nerved, and awnless. Palea is prominent and as long as the lemma. Seeds are free from lemma and palea, falling readily from the spikelet at maturity.

Sand dropseed is a perennial grass usually occurring in tufts, 12 to 40 inches (30 to 100 cm) tall (fig. 17). Leaves are 0.08 to 0.2 inch (2 to 5 mm) wide, more or less involute in drying and tapering to a fine point. Sheaths have a conspicuous tuft of long, white hairs at the summit. Panicles are usually included at the base. This species is widely distributed throughout the United States, and occurs in all the western range States. It is also a warm-season grower and may have two or more reproductive phases if precipitation is favorable. Because the foliage is palatable to livestock, it is often overgrazed. However, sand dropseed is a prolific seeder and can increase in depleted ranges under good management.

Sporobolus airoides **(alkali sacaton)**.—This bunchgrass is a robust, spreading, perennial 20 to 40 inches (50 to 100 cm) tall (fig. 18). Sheaths are pilose at the throat, and ligules are also pilose. Leaves are elongate, flat, but soon becoming involute, usually less than 0.16 inch (4 mm) wide. Panicles are nearly half the length of the plant with stiff, slender, widely spreading branches. A common habitat is alkaline flats where it sometimes occurs in nearly pure stands. It also grows in nonalkaline plains and valleys. Alkali sacaton is widely distributed throughout the West from Washington to South Dakota and western Texas to California. Its coarse foliage is readily eaten by cattle and horses, but is poor forage for sheep.

Bouteloua gracilis (**blue grama**).—Another warm-season grass frequently associated with salt-desert shrub vegetation, blue grama is a closely tufted perennial 8 to 20 inches (20 to 50 cm) tall (fig. 19). It is leafy at the base with flat or loosely involute blades 0.04 to 0.08 inch (1 to 2 mm) wide. Each slender stem typically bears two falcate spikes 1 to 2 inches (2.5 to 5 cm) long, with a rachis that does not extend beyond the spikelets. It occurs on plains and foothills in dry, sandy, or gravelly soils as well as compact loams and gumbos. It is widely distributed throughout the West and the Great Plains. Blue grama is a valuable forage for all kinds of livestock in most situations, but is used only lightly on Great Basin winter ranges.

Oryzopsis hymenoides (**Indian ricegrass**).—This hardy, densely tufted perennial bunchgrass grows during the cool season in several salt-desert shrub communities and elsewhere throughout the Western United States (fig. 20). Like other species of the genus, its spikelets are one-flowered, disarticulating above the glumes. Leaf blades are slender, involute, and nearly as long as the culms. Its panicle is diffuse, 2.8 to 6 inches (7 to 15 cm) long, with slender, dichotomous branches. Ricegrass is highly palatable to all classes of livestock in both green and cured condition.

Sitanion hystrix (**bottlebrush squirreltail**).—A bristly headed, perennial bunchgrass, 4 to 20 inches (10 to 50 cm) tall (fig. 21), this plant's leaves are glabrous or puberulent to densely white-pubescent, 2 to 8 inches (5 to 20 cm) long and 0.04 to 0.12 inch (1 to 3 mm) wide. Spikes are erect, 0.8 to 2.8 inches (2 to 7 cm) long or longer, the rachis disarticulating at the nodes. It is widely distributed throughout the West on dry, gravelly soils or alkaline conditions. Bottlebrush squirreltail is only moderately palatable to livestock during most seasons, but it is a valuable winter forage. The basal leaves begin to grow in late fall, and often remain green and succulent through the winter. Sheep relish this green foliage, and consequently only scattered plants remain on heavily grazed winter ranges.

Perennial Forbs

Broadleaf, herbaceous plants, commonly known as forbs, are not prominent in most salt-desert shrub communities. Although numerous annual forbs may be present in substantial amounts, especially in years of favorable moisture, perennial species are generally unimportant. At least one species, however, is worthy of note:

Sphaeralcea grossulariaefolia (**gooseberryleaf globemallow**).—This is a grayish-stellate, erect, perennial forb 12 to 28 inches (3 to 7 dm) tall (fig. 22). Leaf blades are 0.8 to 2.6 inches (2 to 5 cm) long, three-parted, the lower division again deeply cleft. Inflorescences are interrupted and compound. Petals are reddish and 0.4 to 0.8 inch (1 to 2 cm) long. Carpels (fruit) are two-seeded, rugose-reticulate; seeds, mostly pubescent (Hitchcock and others 1961). It is widely distributed from Idaho and Washington south to New Mexico and Arizona on salt-desert shrub and adjacent sagebrush-grass ranges. It is a desirable forage species, especially on salt-desert winter ranges. Because globemallow is a short-lived plant, perpetuation requires favorable conditions for its establishment every 2 or 3 years.

Annuals

Although native annuals are not especially important on salt-desert shrub ranges, three introduced species—cheatgrass, Russian thistle, and halogeton—have invaded large areas of salt-desert winter range. These species have often replaced desirable native forage plants as the latter were weakened or killed by abusive grazing, weather, or other factors. Production of these species varies tremendously from year to year.

Bromus tectorum (**cheatgrass**).—This erect winter or summer annual is 12 to 24 inches (30 to 60 cm) tall, with pubescent sheaths and blades. Panicles are 2 to 6 inches (5 to 15 cm) long, rather dense, soft, and drooping, and often purple during early stages (fig. 23). It is widespread throughout the United States, especially in the West where it has invaded and sometimes replaced the native vegetation on millions of acres of sagebrush-grass, salt-desert shrub, and other ranges. On salt-desert shrub ranges, cheatgrass is particularly prominent in the shadscale and black sagebrush communities. Despite its many undesirable qualities, it can supply reasonably good forage and ground cover for soil stabilization.

Salsola iberica (**Russian thistle**).—The plant is a bushy-branched annual up to 20 inches (5 dm) high and 2.5 ft (7 dm) broad (fig. 24). However, on poor sites or crowded conditions, size is greatly reduced. Russian thistle is at first soft and succulent but becomes rigid with maturity. The many sessile, slender, alternate leaves become prickle-tipped. Flowers are small, papery, and inconspicuous, growing in the axils of spiny leaf clusters (Dayton 1960). Russian thistle flourishes on good sites but may not occur there because of competition from other plants. It is somewhat salt resistant and grows on some coarse-textured alkali soils, and often forms pure stands on overgrazed areas. Growth is especially profuse in some depleted winterfat and big sagebrush communities whenever summer precipitation is ample. When young and succulent, it provides good forage, but quality deteriorates greatly with maturity. Palatability is improved by softening following winter storms.

Hologeton glomeratus (**halogeton**).—This is a fleshy annual (fig. 24) with small, fingerlike leaves; flowers without corolla, five sepals and five stamens. Seeds are borne in a small, flattened utricle (Dayton 1960). Halogeton is a prolific seed producer. Seeds are black or brown (Cronin and Williams 1966). Black seeds, which germinate whenever moisture and temperature are favorable, are viable for about 1 year and provide a means of rapid spread. Brown seeds do not germinate readily, and they persist in the soil for at least 10 years, providing a means of species survival during extended periods of severe drought. Because of its relatively high oxalate content, halogeton is especially poisonous to sheep, and losses can be severe when hungry animals graze where good forage is lacking.

PLANT COMMUNITIES

Although description and ecology of salt-desert shrub vegetation have received considerable attention since the 1910's, a comprehensive effort has not been made to develop a usable classification system. West and Ibrahim (1968) made a study of soil-vegetation relationships in the shadscale zone of southeastern Utah and described four habitat types (h.t.) with distinctly different floristic composition and soil characteristics. These are: *Atriplex confertifolia-Hilaria jamesii*, *Atriplex nuttallii* var. *nuttallii* (now *A. tridentata*)-*Hilaria jamesii*, *Atriplex nuttallii* var. *gardneri* (now *A. gardneri*)-*Aster xylorhiza* (woody aster), and *Atriplex corrugata* (fig. 25).

Numerous salt-desert shrub communities have been named, described, and studied, and they provide a basis for identification of particular units and extrapolation of information. They vary from almost pure stands of single species to fairly complex mixtures. The characteristic mix of low shrubs and grasses is sparse, with large open spaces between the plants. Ground cover usually varies between 2 and 8 percent. The interspaces between the plant clusters are commonly covered by a microphytic crust (West 1982a), and the surface will be soft if the site has not been compacted by trampling of animals or wheels of vehicles. Wagner (1980) speculates that microphytic crusts of these communities may functionally substitute for the organic mulch layer of more mesic systems. Plant communities are normally distinct, but sometimes merge imperceptibly into one another.

The following list shows some 28 salt-desert shrub communities, each of which is treated in some degree by one or more investigators (Billings 1945; Fautin 1946; Hutchings and Stewart 1953; Kearney and others 1914; Singh 1967; Shantz and Piemeisel 1940; Stewart and others 1940; Vest 1962; West and Ibrahim 1968; and Wood 1966):

Shadscale
Shadscale-grass
Shadscale-winterfat-grass
Shadscale-winterfat
Shadscale-gray molly
Shadscale-gray molly-greasewood
Shadscale-budsage
Winterfat
Winterfat-low rabbitbrush-grass
Winterfat-grass
Budsage
Budsage-winterfat
Budsage-hopsage-greasewood
Budsage-gray molly
Greasewood
Greasewood-shadscale
Gray molly
Gray molly-Gardner saltbush-winterfat
Black sagebrush
Black sagebrush-shadscale-grass
Low (little) rabbitbrush
Low rabbitbrush-winterfat-grass
Hopsage
Fourwing saltbush
Mat saltbush
Gardner saltbush
Gardner saltbush-woody aster
Saltsage-galleta grass

Obviously, this list is far from complete, with probably less than half of the existing communities included. Because of numbers involved, the mosaic of small and variable communities, and the lack of classification by habitat types or range sites, individual management prescriptions apparently cannot be developed for or applied to each shrub community. Only guides for salt-desert shrub ranges in general are possible.

While absence of long-time use and vegetation records, generally poor correlations between vegetation and soil, and other unknowns make interpretation of change difficult, several areas, particularly in Utah, have been the object of intensive and sometimes long-term study. On such areas, stability of the vegetation and changes as a result of grazing or weather can be predicted with reasonable accuracy.

Shadscale is the dominant plant on extensive areas of salt-desert shrub range. It forms almost pure stands on deep, well-drained soils in valley bottoms (fig. 26), and on higher slopes is mixed with other shrubs and grasses (Hutchings and Stewart 1953). On the Desert Experimental Range, two communities—shadscale-winterfat-grass (fig. 27) and shadscale-grass (fig. 28)—cover about half of the land area. Grasses such as Indian ricegrass or galleta often occur. Shadscale suffers more from prolonged drought than any other of the salt-desert shrubs (Vest 1962). Where grazing has been excessive, palatable grasses and shrubs have often been replaced by shadscale, which is protected from grazing by its lower palatability and by sharp thorns. Shadscale also forms communities with gray molly and with budsage, but usually it maintains dominance because of its greater size and density. The prevailing color of most shadscale communities is dull, grayish green, but in autumn turning to yellow, reddish brown, and purple hues (fig. 26).

Winterfat communities are second only to shadscale in the salt-desert shrub areas. They exist as almost pure stands on dry, alluvial soils near valley bottoms (fig. 29) and as mixtures with other species on the lower valley slopes. Low rabbitbrush is a common, though less desirable, member of winterfat communities, and such desirable species as Indian ricegrass, galleta, and black sagebrush are frequent associates (fig. 30). Although winterfat shoots have a blue-green color, this is mostly hidden by a soft, white wool. It is a palatable and nutritious plant.

Budsage occasionally grows in nearly pure stands, but usually is found as a member of many other salt-desert shrub communities, where it is often a codominant with such species as winterfat, hopsage, greasewood, shadscale, gray molly, and grasses (fig. 31). Budsage is often found in piedmont areas, where soils are loamy with occasional gravel, and upper layers are low in salt content. Because of its drab appearance during most of the year, budsage has little effect on the overall appearance of the communities in which it occurs. However, in early spring its dark green foliage and yellow blossoms (fig. 12) present a somewhat colorful aspect that lasts until early June. It provides nutritious and palatable forage, especially during active growth in early spring.

Greasewood communities (fig. 32) normally occupy the lower, finer textured, more saline soils where soil moisture supply is increased by a high water table (Shantz and Piemeisel 1940) or by supplemental runoff water from other areas (Vest 1962). With reference to other communities, it lies below shadscale and slightly above the saltgrass (*Distichilis* spp.) and pickleweed (*Allenrolfea occidentalis*). However, between the zones of greasewood and shadscale are wide tracts of a greasewood-shadscale mixture (fig. 33), where adequate soil moisture is available for the deep-rooted greasewood and surface layers are dry enough to permit growth of shadscale. Greasewood also occurs on windblown hummocks, where it is mixed with sagebrush, rabbitbrush, and fourwing saltbush. Because of its bright green, succulent leaves and generally large size, greasewood adds variation to otherwise drab vegetation. Because both greasewood and shadscale are low in palatability, such communities provide only limited forage for livestock.

Gray molly occurs in almost pure stands resembling winterfat (fig. 34), but also is commonly found in mixtures with shadscale, budsage, winterfat, galleta, or Sandberg bluegrass (fig. 35). However, because of its small size and drab appearance, gray molly is usually an inconspicuous member of such communities. Gray molly normally grows in fine-textured, close-structured soils containing little or no gravel. It provides fair forage for livestock, especially sheep, but associated species are usually more important for this purpose.

Black sagebrush communities (fig. 36) are productive, and consequently desirable as winter range. They normally grow on rocky soils of the higher valley lands and foothills where soil is well drained and soil salts are not excessive. However, a caliche layer is often present at a depth of about 18 inches (45 cm) or less. Species such as squirreltail, Indian ricegrass, Sandberg bluegrass, galleta, budsage, winterfat, and low rabbitbrush are often intermingled (fig. 37). Black sagebrush communities are not only productive but also provide a good selection of palatable species. They are especially valuable for sheep and antelope.

Low rabbitbrush communities (fig. 38) occupy the upland parts of the valleys and consequently are closely associated with black and big sagebrush communities. Although low rabbitbrush may occur in nearly pure stands, more often it is mixed with winterfat, sagebrush, galleta, Indian ricegrass, sand dropseed, globemallow, and sometimes shadscale (fig. 39). Despite its dark green foliage, communities dominated by low rabbitbrush often appear light green because of straw-colored inflorescence retained from the previous fall. During flowering, however, these areas are a mass of golden yellow. Soil texture of land occupied by low rabbitbrush is fairly coarse but may not be greatly different from adjacent communities. Because it is less palatable to livestock than most associated species, low rabbitbrush often increases as grazing pressures reduce the preferred plants.

Spiny hopsage is one of the most palatable of the salt-desert shrubs. Although it often occurs in fairly pure stands, it is sometimes in mixtures with budsage, greasewood, low rabbitbrush, and grasses (fig. 40). Hopsage apparently prefers sandy soils, free of salt and hardpans. Because it is usually grazed heavily by livestock in spring and early summer, hopsage is being replaced by such unpalatable species as low rabbitbrush. Careful management will be necessary to maintain satisfactory stands of this valuable species.

Fourwing saltbush is widely distributed throughout the West, especially in sagebrush-grass and salt-desert shrub communities. Frequent associates are big sagebrush, shadscale, Gardner saltbush, winterfat, rabbitbrush, and a variety of grasses (fig. 41). Although it frequently occurs on sandy soils, it is not confined to such areas and is often found on heavier soils intermediate between saline and nonsaline areas, alternating with greasewood-shadscale and winterfat communities. Because of its high productivity, palatability, adaptability, and nutritional qualities, fourwing saltbush and associated communities are especially valuable as livestock range, wildlife habitat, and for soil stabilization. Unfortunately, it has virtually disappeared from some areas as a result of yearlong grazing by cattle.

Plant communities dominated by mat and Gardner saltbushes and saltsage are not widely distributed in the Great Basin Desert, but are important on localized areas. They may be found in almost pure stands, but also in mixtures with galleta, woody aster, budsage, and globemallow. In eastern Utah, saltsage communities are found on eroded pediment slopes, and Gardner saltbush communities are associated with Mancos shale badlands, whereas mat saltbush communities are restricted to the alluvial soils. All of these communities furnish winter forage for sheep.

CLIMATE

As the name implies, the salt-desert shrub region is arid. Lying far from the oceanic sources of atmospheric moisture and in rain-shadows of high mountain ranges, this desert receives little precipitation. The average annual amount is generally less than about 7 inches (17 cm). The amount received in any year, however, might be less than half or more than twice the average for a given site.

Over a large part of the geographical range of salt-desert shrub vegetation, there is little suggestion of seasonal pattern of occurrence of precipitation. Climatic diagrams do indicate that toward the northwesterly part of the region, a moist period is to be expected in the cold part of the year, and toward the southeasterly part, the period of greatest moisture will be mid- to late summer (Visher 1966 and Houghton and others 1975). Toward the northeast there tends to be a late-spring moist period. But plotted seasonality of occurrence is probably of less importance on this desert than in other ecosystems because desert precipitation comes with an extreme irregularity that does not appear in graphs of long-term seasonal or monthly averages. Any month or season, even the one that is the driest on the average, may be the wettest in a particular year, and vice versa.

The latitude and the elevation of the salt-desert shrub area control its temperature. This "cold desert" has warm rather than hot summers and cold winters with several weeks of temperatures below (usually much below) freezing. Over the wide geographic range of the desert, again because of latitudinal and elevational variation and also because of local relief and aspect of the land surface, there is variation in length of the summer frost-free period, usually between 100 to 150 days. The term "frost-free period" has less significance for desert vegetation than for many agricultural crops because many desert plant species grow when daytime temperatures are above the freezing point and the soil is unfrozen, but the night or early morning temperatures fall below the freezing level. Frost-free time in arid country is by no means synonymous with "growing season." The presence or absence of moisture determines whether plants will grow when the temperature is optimum.

The desert is sunny, more so in summer than in winter, and the relative humidity of the air is low. Wide daily ranges in temperature are therefore common on the desert, particularly in the valleys of interior drainage. Differences between day and night temperatures of 45 °F (25 ° C) are not uncommon when the sky is clear (Environ. Data Serv. 1968).

Winds are a usual feature of the desert. They are often strong and steady for several days at a time, especially prior to arrival of a storm front. In the warm part of the year, their effect is a hastening of soil moisture depletion and a consequent reduction of its effectiveness for plant growth. A strong wind, when the surface soil is dry, can be a soil-eroding agent. However, except for certain dune areas and playas, wind itself is not the primary cause of wind erosion. Soil stability is a function of range management in the salt-desert community. Winds that accompany some of the light snowfalls of winter, causing small drifts to form in the lee of plants, are beneficial in providing deeper, although local, penetration of moisture into the soil for greater effectiveness in promoting plant growth. Livestock and wildlife use small drifts as a water resource, accessible for several days or weeks.

Weather-Plant Growth Relations

Desert plants grow when the temperature is favorable, but only if there is soil moisture available at the same time. Because the moisture regime is so variable from year to year, and different species flourish under different seasons of soil moisture, there is irregularity in thriftiness of species and combinations from year to year. Only rarely do all components of the vegetation thrive at their best in the same year.

Some perennial species such as budsage and hopsage make all their growth, including the reproductive phases of flowering and fruiting, in the early part of the warm season. Some of them begin to grow weeks before the end of the time of nightly frosts. A few species shed their leaves and become dormant before the hottest days of summer, while others may remain green. Some actually continue to grow, if moisture is available, but dry into dormancy if the soil moisture is depleted. Other species such as black sagebrush and low rabbitbrush begin growth early, yet flower in late summer and fruit in the fall. Still others wait for the frost-free period to start growth. These species usually require only a few weeks to complete a cycle of vegetative growth and reproduction. In years when the pattern of rainfall makes it possible, there may be more than one growth cycle, even three or four for these warm-season growers. Plants such as winterfat and globemallow are similar to these warm-season growers in that their reproductive development is timed by rains and warm-season soil moisture rather than season or year. But these species also grow well vegetatively in the colder weather of early spring and late fall.

The desert annuals can also be grouped by season of growth and flowering. However, unlike perennials, the presence or absence of certain annuals depends on weather. Rains must provide moisture for germination and seedling establishment at the right season if certain plants are to appear at all in a given year. The so-called winter annuals are present only in years when rains of the previous fall were early enough and sufficient for seed germination. Some summer annuals germinate in the cool early spring weather, but only when soil moisture is also near the surface. These make little above-ground growth before early summer, growing more rapidly later. Other species germinate and establish seedlings only in late spring or summer.

The winter annuals all flower and fruit in the spring and die by the time of warm summer weather. The early spring germinators generally have their specific seasons for reproduction: midsummer or fall. Those that germinate with warm-season rains rapidly go into a reproductive phase. If the rains continue with the right frequency and amount, these species continue to increase in size and to flower and fruit over a considerable length of time. Establishment of new perennial plants, which is by seed for almost all the desert species, is similar to that of annuals.

Because rainfall for soil moisture varies in amount from year to year, total growth of vegetation, regardless of species making up the type, also varies (see material on stocking rate in section on "Recommended Grazing Management.") Although the high annual precipitation may be three or four times the low, the above-ground yield of vegetation during high years may be more than six times greater than the low.

Not all areas produce annuals. This is especially true where the perennial community is vigorous and essentially closed to establishment of new plants. However, in areas open to annual plant establishment, the difference in annual plant yield from year to year may vary by several hundred times. This is due not only to different amounts of precipitation, but also to the time pattern in which it occurs.

Soil Moisture Accumulation and Depletion

Because in cold weather evaporation stress is low and plants are not transpiring, winter is a period of soil moisture accumulation and storage. It lasts from 4 to 7 months, so a good likelihood exists that during such a long time there will be at least one storm with sufficient precipitation to supply effective amounts of water. Depending on the amount actually received during winter, the depth of water penetration at the time of early spring plant growth may be as little as a few inches or as much as 3 ft (1 m) or more, and spring plant growth will reflect the amount of accumulated winter moisture. Unless more rains come in the spring, the soil moisture will be depleted in a few weeks and growth will slow and ultimately cease, and the perennial plants will assume their various forms of dormancy. If effective rains come later in the warm season, some of the species will renew their growth from the stage at which it had stopped. Others, having died back, will start over as if emerging from winter dormancy. Some cool season plants that become dormant during spring drought before reaching their reproductive stage fail to show that stage of growth when summer rains do occur. Some grow vegetatively and others show no growth at all.

Moisture stored in the upper 2 to 3 inches (5 to 7 cm) of the soil is of little or no benefit to the plants. This layer, nearest to the drying effect of winds, rises many degrees higher than the air temperature in the sunlight and loses its moisture in 2 or 3 days during the warm season. This zone is essentially devoid of feeder roots (Holmgren and Brewster 1972). For a warm-season (spring, summer, fall) rain to be useful for plant growth, its volume must be sufficient for soaking below this layer. For most dry desert soils, the minimum amount of rain needed for penetration of moisture to effective depths is 0.25 to 0.4 inch (0.6 to 1 cm), but growth is seldom observed after precipitation of less than 0.6 inch (1.5 cm). Effective amounts in summer are from thunderstorms when some areas may receive rain a number of times while neighboring areas receive little or none. These storms are more common in the eastern and southeastern parts of the salt-desert shrub region than in the northwestern parts (Visher 1966). The warm-season species comprise a more important part of the vegetation in the area of greater summer rain expectancy than elsewhere.

If plants have not completely depleted the moisture supply by the time of soil moisture recharge—that is, if the vegetation has not become summer-dormant when the rains come—a greater proportion of the moisture is available for use by the plants because its use is immediate. If, on the other hand, the plants are mostly dry or with few remaining green leaves, transpiration will at first be rather slow, and a greater amount of the total water will be lost to the atmosphere by evaporation. This is true especially of moisture in the top 6 inches (15 cm) or so of the soil profile.

Probably less than half the moisture that comes in the warm half of the year is effective for plant growth. Almost all the water from storms of less than 0.2 inch (0.5 cm), unless they follow one another on consecutive days, is reevaporated. Some storms much wetter than that are less effective than the amount of rain they bring would suggest. These are the very high-intensity storms with rainfall rates in excess of soil infiltration rates (fig. 42) that result in overland runoff and flash flooding. Water loss by overland flow is more common on slopes than on flats, but storms that cause flood-water loss are still effective for plant growth on the site of the storm because a part of what falls goes into the ground.

Weather and Animals

Animals, as well as plants, exhibit wide fluctuations in productivity from year to year, largely as a result of varying weather conditions. For instance, obvious annual differences occur in the presence and abundance of several common insect species. Some of the variation may be a direct effect of either temperature or precipitation. Some may be an indirect effect, the result of the weather's effect on the vegetation, the habitat, and food supply of the insects.

Insects are in the food chain of lizards, small birds, and some small mammals. The birds and most mammals also depend greatly upon seeds; and seed production, as does productivity of vegetation in general, varies with weather. Because a number of species do not produce any seeds in dry years, wide population differences among years for these small vertebrates may be attributable, at least in part, to effects of weather on the food supply. At the Desert Experimental Range, Beale and Holmgren (1979) found much higher populations of kangaroo rats in the wetter-than-average year, 1978, than in the dry years of 1976 and 1977. The population of jackrabbits also rose dramatically, approximately fivefold, in that year of good plant productivity.

Spring snowstorms, rather unusual events on the desert, are known to have adverse effects on the success of ground-nesting birds and larger animals. Several pronghorn fawns only a few days old died as a result of the storm of May 19-20, 1975 (Beale and Holmgren 1979).

In their study with pronghorns in the desert of western Utah, Beale and Smith (1970, 1973) considered a number of weather-related aspects of herd productivity. In summers when the succulence of the forage plants was high (over 75 percent moisture) because of summer precipitation, the animals did not drink much water. In dry summers, when the forage moisture content was low, the pronghorns drank about 3.2 qt (3 liters) of water per day. Beale and Holmgren (1974) reported that as daily maximum temperatures became higher, in the range of 70° to 100° F (21° to 38° C), an additional liter of water was consumed for each increase of about 3° C (1 qt for each increase of 6° F), whether the animals were on fresh natural feed or on hay with a grain supplement.

The diet of the pronghorns varies with the year (Beale and Smith 1970). In summers of above-average rainfall, the diet is more than 90 percent forbs. In dry years, when forb production is low, these plants contribute less than 20 percent of the diet; browse makes up the remainder of the summer diet. Beale and Smith (1970) reported that succulence appeared to be the major characteristic of the forage sought by pronghorns.

These same workers (1973) suggest a relation between forage conditions (and hence animal condition) of late summer and fall and the size of fawn crop the following spring, with a significant correlation between the June-through-September precipitation of 1 year and the ratio of fawns dropped per breeding doe the next spring. They also noted that when scattered summer storms resulted in local areas of abundant green growth, animals selected these areas for feeding. A possible indirect relation between weather conditions and loss of fawns to predators was also indicated: During dry summers with poor forage conditions, pronghorns tended to move to the higher elevations among the hills where the terrain is broken and fawns are more vulnerable to predation (Beale and Smith 1970).

Livestock use desert ranges mostly in winter, and grazing practices must be compatible with weather conditions. (The wide variation in forage production and the attendant problems of setting stocking rates are discussed in the section on "Recommended Grazing Management.") Snow in small or moderate amounts is desirable because it enables the animals to graze areas that would be unusable otherwise. Distribution of the animals into such parts of the range lessens the grazing pressure on areas nearer to locations where water can be provided. In some years deep snowfall will make the forage inaccessible, necessitating the use of supplemental feed to save the animals from starvation.

During clear weather, especially in winter and particularly in the Great Basin, when a high-pressure atmospheric condition exists, low-level temperature inversions develop. This makes night and early morning temperatures of the lower parts of valleys as much as 30° F (17° C) colder than those of the slopes at higher elevations (Houghton and others 1975). When there is a blanket of snow, the inversion persists throughout the day. Sometimes during such low-level inversions, the air of the valley bottoms may be foggy as well as cold. In order to maintain body heat, livestock seek the more comfortable areas such as higher slopes during inversions and sheltered coves and hillsides during windy periods.

SOIL-VEGETATION RELATIONS

According to West (1982a), the salt-desert shrub ecosystem occurs mostly in two kinds of situations that promote extreme soil salinity, alkalinity, or both: the bottom of drainages in enclosed basins or where marine shales outcrop. However, Billings (1945) noted that salt-desert shrub vegetation in western Nevada occupies not only the dry lake-laid sediments with mild concentrations of subsoil salt, but also the dry salt-free residual and fan soils of the foothills and lower mountain ranges where precipitation is under 6 inches (15 cm) per year. In other words, salt-desert shrub vegetation may be an indication of climatically dry as well as physiologically dry soils. Naphan (1966) added that not all salt-desert shrub soils are salty and that their hydrologic characteristics may often be responsible for associated vegetation. The capacity of soils to supply moisture to plants, then, may be strongly influenced by an excessive quantity of soluble salts throughout or in some part of the soil profile, by critical limitations in their hydrologic characteristics (infiltration, permeability, water-holding capacity), or simply by amount of precipitation.

For the most part, salt-desert shrub soils have carbonates accumulating not far beneath the surface (Billings 1949). In many cases the pan layer is not strongly cemented and does not seriously impede root development. The soils are usually light in color, ranging from an ash gray to a light buff. Apparently, presence of salts in the subsoil is a rather common characteristic, depending upon the origin of parent material and weakness of leaching.

Many terms have been used to describe soil conditions of salt-desert shrublands locally and in the literature. According to Bower and Fireman (1957) and the USDA Soil Survey Staff (1962), **saline** soils contain excessive amounts of soluble salts only, whereas **alkali** soils contain either an excessive amount of adsorbed sodium or a high degree of alkalinity (pH of 8.5 or higher). Sodium adsorbed by soil particles is also referred to as exchangeable sodium, which usually amounts to 15 percent or more in alkali soils. Locally, **alkali** has been used for all of these conditions, with **white alkali** referring specifically to soils now defined as **saline** and **black alkali** as roughly equivalent to **alkali** soils. Saline soils are usually friable with a structure favorable to movement of water and air, and may have salt crusts on their surface, whereas alkali soils are darker in color and have a tight structure that prevents penetration of air and water.

Although many kinds of soil occur in the salt-desert shrub ecosystem, the most important can be included in 3 orders, 6 suborders, and 12 great groups of the National System of Soil Classification (Naphan 1966). These are listed in table 1. Aridisols comprise the major area of salt-desert shrublands. They have been subjected to more intensive weathering than soils of the other two orders and have lighter colored surfaces. The most extensive great groups of this order are Calciorthids with a calcic or gypsic horizon within 40 inches (1 m) of the surface, a vescicular crust, and gravel pavement; Camborthids with only a cambic horizon, favorable infiltration and water-holding capacity; Natrargids with a natric horizon ranging from clay loam to clay, slow permeability, and soluble salts increasing with depth; and Haplargids with an argillic horizon sometimes underlain by a calcic horizon and moderate concentrations of soluble salts. Young soils of the order Entisols occupy a considerable area of bottomland flooding, and within this order Torrifluvents are the most common.

Because composition and productivity of vegetation in the salt-desert shrub ecosystem are obviously related to soil characteristics, these associations have been the object of considerable study. The mosaic of plant communities and the frequent distinct boundaries between them have been of particular interest because such vegetation zonation has usually been attributed to edaphic factors. Species of the salt-desert shrub complex have different degrees of tolerance to salinity and aridity, and they tend to sort themselves out along a moisture/salinity gradient (West 1982a). Branson and others (1967) concluded that soil-moisture relationships are the primary cause of different plant communities. They suggested that soil salts also appear to be important as a cause of community differences. However, the major effects of salts is not osmotic stress directly, but its contribution to total soil-moisture stress.

From studies in western Utah, Gates and others (1956) showed some significant differences between soils of plant communities dominated by big sagebrush, shadscale, Gardner saltbush, winterfat, and greasewood. However, no species was restricted by a narrow tolerance range for any specific soil factor. Overlap of each soil factor measured was found under all species studied. With certain ranges for each edaphic factor, it would be logical, therefore, to find mixtures of the various species, but this was not so. Apparently, factors not measured must have limited the vegetation to single species.

Of the species studied, big sagebrush was found on soils with the lowest amounts of soluble salts and on the finest textured soils—a situation somewhat different from that of earlier investigators. In the salt-desert shrub area, sagebrush apparently has only limited value as an indicator of soil conditions.

Winterfat occurred on soils relatively low in amounts of salt and sodium. These soils were coarser in texture with lower field moisture capacity. However, the species

Table 1.—*Classification of the major soils of the salt-desert shrub area in orders, suborders, and great groups of the National Soil Classification System (from Naphan 1966)*[1]

Order[2]	Suborder[3]	Great Group[4]	Subgroup[5]	Family[6]	Series[7]
Entisols	Psamments	Torripsamments			
	Fluvents	Torrifluvents			
	Orthents	Torriorthents			
Inceptisols	Aquepts	Halaquepts			
Aridisols	Orthids	Calciorthids			
		Camborthids			
		Durorthids			
		Salorthids			
	Argids	Nadurargids			
		Durargids			
		Natrargids			
		Haplargids			

[1]Names of suborders and great groups are tentative and subject to revision.
[2]Groupings made primarily on generalization of common properties.
[3]Differentiated on: (1) chemical and physical properties that reflect either water-logging or genetic differences due to climate and vegetation, or (2) chemical or mineralogical properties that include extremesof textures and presence of large amounts of amorphous clays or free sesquioxides in the clay fraction.
[4]Subdivisions of suborders based largely on the presence or absence of diagnostic horizons (argillic, calcic,and so forth) and the arrangement of these horizons.
[5]Subdivisions of the great group including a central concept of the great group and fringe subgroups where properties of one great group tend to merge with others.
[6]Subdivisions of subgroups that are differentiated primarily on the basis of properties important to the growth of plants—texture, mineralogy, water holding capacity, soil temperature, reaction, and so forth.
[7]A collection of soil individuals essentially uniform in differentiating characteristics and arrangement of horizons.

was not restricted to such soils but grew under widely variable conditions. Apparently, winterfat is a poor indicator of soil characteristics. Presumably, both winterfat and sagebrush are restricted by high amounts of total salts and sodium.

Shadscale occupied soils of intermediate salt and sodium content. These soils were nonsaline at the surface, but saline-alkali at greater depths. They also were low in water-holding capacity, suggesting adaptation of shadscale to coarse-textured soils. However, the great variations in shadscale soils severely limit the use of this plant as an indicator of soil characteristics.

Fine-textured soils associated with Gardner saltbush were saline in the surface 6 inches (15 cm) and saline-alkali to depths of 5 ft (1.5 m). However, tolerance of this species to a wide range of soil conditions makes it a poor indicator.

Soils of greasewood communities were of relatively fine texture, saline throughout the profile and saline-alkali below the surface 6 inches (15 cm). Because greasewood occupies soils with wide and varied amounts of salinity and alkali, it is not an infallible indicator of salt or other soil conditions. From the results of this research, Gates and others (1956) concluded that vegetation of Utah salt-desert is not an adequate index for identifying soil characteristics or for predicting potential capabilities of the land.

To supplement previous studies of salt-desert shrub vegetation in relation to moisture and chemical properties of the soil, Mitchell and others (1966) analyzed physical properties of soil associated with shadscale and winterfat communities in northwestern Utah. They were unable to find a close relation between the vegetation mosaics and soil properties. They concluded that the soil had no obvious influences on vegetation of these two communities, and that the vegetation had not induced soil changes during the involved period of soil development.

Several explanations are possible for the lack of precise correlations between vegetation and soil. The vegetation mosaic may be a result of past rather than present environmental factors. Because sorting of species may follow different sequences in different locations, some of the lack of predictability may be due to ecotypic variation (West 1982a). Successional status of salt-desert shrub communities is not well known for most areas. Consequently, a particular community may be merely expressing a deteriorated condition of another. This makes classification by habitat types or range sites extremely difficult. Apparently, one environmental factor can compensate for another, and vegetation is an indicator of the whole environment and not just of climate or parent material or soil or any other single factor (Billings 1952).

Reasonably close correlations of landscape and soils with salt-desert shrub vegetation in southeastern Utah were found by West and Ibrahim (1968), who identified and described four distinctive units as habitat types (h.t.). The *Atriplex confertifolia/Hilaria jamesii* h.t. occurs on level pediment remnants where coarse-textured and well-developed soil profiles were derived from sandstone gravel. Soils of this community are nonalkali throughout the profile, and nonsaline in the surface 2.5 ft (75 cm) but saline at greater depths. A distinct lime zone about 1 ft (30 cm) thick occurs from 15 to 30 inches (37 to 75 cm) below the soil surfaces. The *Atriplex* *nuttallii* var. *nuttallii* (now *A. tridentata*) /*Hilaria jamesii* h.t. occurs on eroded pediment slopes where a shallow vesicular horizon overlies a massive gypsiferous horizon and altered bedrock of Mancos shale. The profiles are loamy and nonalkali throughout, nonsaline in the surface 15 inches (37 cm), but saline at greater depths. The *Atriplex nuttallii* var. *gardneri* (now *A. gardneri*) /*Aster xylorhiza* h.t. occurs on lower Mancos shale badlands. Soil profiles are typically fine textured and nonalkali throughout, nonsaline in the surface 1 ft (30 cm), but saline at greater depths. The *Atriplex corrugata* h.t. is found on areas of alluvium where material from the other three habitat types have been deposited over Mancos shale. Soils are fine textured and saline-alkali throughout the profile.

In an unpublished study of soil-vegetation relations at the DER, V. K. Hugie (personal communications 1982) and K. W. Flach observed the range of soil characteristics associated with plant communities dominated by winterfat. Areas sampled ranged from upland alluvial fans to valley bottoms, and included gravelly loams, gravelly sandy loams, gravelly fine sandy loams, sandy loams, very fine sandy loams, and silt loams belonging to the Camborthid, Paleorthid, Calciorthid, and Torrifluvent great groups. All are friable and moderately alkaline (pH between 8.0 and 8.6). Carbonate accumulation of the Camborthids is not sufficient to produce a calcic horizon, which is well developed in both the Paleorthids and Calciorthids. Similar winterfat communities occur across these variations in texture, great groups, pH, and carbonate accumulation (fig. 43).

Because black sagebrush and winterfat often grow in alternes, V. K. Hugie and K. W. Flach (unpublished data) compared soils of winterfat communities and those of adjacent sagebrush. Although the soils are similar in many respects, two major differences were observed: Depth to the calcic horizon was much shallower under black sagebrush (about 2 ft or 60 cm), and calcic horizons under black sagebrush were weakly cemented whereas those under winterfat were compact and indurated (fig. 44).

Although salt-desert shrub vegetation and soils are obviously related, precise correlations are often lacking. Different species and communities may occupy the same soils, or the same species and communities may occupy different soils. In other words, various plants can tolerate a wide range of soil conditions but do not necessarily require them. Species and communities are apparently sorted out along physical, chemical, moisture, and topographic gradients through complex relations that are not understood and are in need of further study.

RANGE CONDITION AND TREND

Range condition or health is the status of vegetal cover and soil in relation to a standard or ideal for a particular habitat type, site, or plant community. Trend is change in condition. Condition and trend are recognizable by certain indicators that can be seen in soil and vegetation. These indicators help to interpret past changes in the ecosystem, and often suggest what may be expected in the future (Ellison and others 1951).

Reliable judgment of condition and trend is essential to effective evaluation of range management practices. Consequently, range managers should be able to identify the plants of their desert communities and know the relative values as forage species, to recognize differences among habitat types or sites, to understand ecological principles including patterns of and reasons for change, and to properly interpret change as a basis for permissible or necessary adjustment in management prescriptions.

Soil stability is an essential requirement of satisfactory condition. In nondesert ranges, plant cover and litter give protection from wind and water erosion. But here, where vegetal cover is normally less than 10 percent, stability of soil in the intervening space is provided by a surface pavement of loose gravels over skeletal soils, or by an almost invisible mat of algae in the surface millimeter where there are no gravel particles (Anderson and others 1982a, Anderson and others 1982b). Both of these protective features can be damaged by animal hooves, and damage is indicated by evidence of active movement of soil by wind or water where trailing and trampling by livestock have been excessive.

Judgement of condition of most ranges is usally made in relation to natural or pristine, the best approximation of the natural state being a relic area never grazed by livestock or otherwise disturbed. However, on the desert such examples are virtually nonexistent. The next-best areas upon which to base judgement are those that have been ungrazed for many years, having had some time to revert toward pristine-like conditions. In some areas old exclosures serve this purpose. Along major highways, with broad fenced rights-of-way, numerous areas are improving in condition and becoming increasingly valuable as sites for comparison. With these one must be careful to discern absence of highway influence, either in the construction phase or as a continuing effect, such as altered drainage or snowpack configuration. Also, some desert areas far from surface waters have had only intermittent use, mostly in the cold season when snow for livestock water was available.

The pristine community or its near approximation is not necessarily the management objective, but serves only as a guide to indicate what quality and quantity of vegetation the area is capable of supporting, character of the litter cover, and normal appearance of the surface soil. Comparisons can be made only between ranges of similar potential. Therefore, judgment of condition should be preceded by classification of range ecosystems into habitat types or range sites. Such classification is far from being accomplished for this desert, so in the meantime range managers must rely on their own judgement of similarity to the best condition or least altered range available for comparison.

Fluctuations in weather are normal events whose effects must be considered when judging range condition. Variations in amount of precipitation and patterns of distribution greatly affect plant development and yield (Blaisdell 1958), but their influence on soil stability and perennial species composition is usually minor.

Trend may involve some degree of change in any component of the ecosystem. For practical purposes, however, only soil and vegetation need be considered in assessment of trend. One must distinguish between those cumulative changes that produce a real difference in condition and those that are mere fluctuations. For example, a large crop of seedlings of desirable perennial species may reflect only a temporarily favorable combination of circumstances. Mortality of perennials is high in their seedling year (West 1979; West and others 1979). Thus, a surer indication of upward trend would be plants of successively older age classes in addition to the seedlings (Ellison and others 1951).

Ellison and others (1951) have made a comprehensive evaluation of 21 important indicators of range condition and trend including cover, bare soil surface, observed movement of soil, trampling displacement, soil remnants, erosion pavement, lichen lines, active gullies, wind-scoured depressions, aeolian deposits, alluvial deposits, vegetal composition, age classes, annual weeds, invasion of bared surfaces, vegetation in gullies, rill-channel ridges, accessibility of palatable species, relics, hedged shrubs, and current use. These indicators provide clues to events that have happened, are happening, or will happen on the range-watershed. Although they have particular application to the Subalpine Zone, most are worthy of serious consideration as indicators of condition and trend on any rangeland being grazed by livestock.

Information on condition and trend of salt-desert shrub ranges is limited largely to results of studies at the Desert Experimental Range in southwestern Utah, where guides were developed by Hutchings (1954). However, these can be broadly used by a manager to make responsible judgments for a variety of plant communities or situations.

Forage production and grazing capacity are influenced by range condition. Therefore, evaluation of condition is an important prerequisite to good management. The criteria or standards used to judge range condition are amount of ground covered by vegetation, presence and relative abundance of undesirable and desirable forage species, vigor of desirable forage species, and extent of soil erosion.

Range condition is usually classified in the general terms: good, fair, poor, and very poor. The following descriptions of these classes are given as general guides to appraise condition of salt-desert shrub ranges:

1. **Ranges in good condition.** Such ranges produce nearly the maximum forage possible under the climatic conditions. Vegetation consists chiefly of a good stand of desirable forage species such as winterfat, black sagebrush, budsage, galleta, Indian ricegrass, squirreltail, hopsage, globemallow, and most saltbushes other than shadscale (fig. 45). These species are thrifty and vigorous and make up a major part of the vegetation. However, in plant communities normally dominated by such species as low rabbitbrush, shadscale, or greasewood, lower amounts of the desirable species are acceptable as good condition (fig. 46). Young plants of desirable species are abundant enough to maintain these species in the community. Swales are vegetated, plants are not pedestaled. Annuals are rare, in most years virtually absent. There is little or no evidence of accelerated wind or water erosion on ranges in good condition. Soil is loose and friable and able to absorb the maximum amount of moisture.

2. **Ranges in fair condition.** The vegetation is being thinned of the most desirable plants, which are being partially replaced by such inferior species as shadscale, low rabbitbrush, and annuals (fig. 47). Too heavy grazing use of palatable plants is apparent. Stubs or dead woody roots of desirable shrubs such as winterfat, black sagebrush, or budsage are scattered throughout the vegetation. Undesirable perennials such as low rabbitbrush and shadscale are becoming more important in the cover, as evidenced by presence of individuals of younger age classes. Annual weeds are common and produce a small proportion of the yield in years favorable for their growth. Soils show some signs of recent erosion, especially where animals have trailed regularly in seeking forage or in areas where they tend to congregate naturally.

3. **Ranges in poor condition.** The desirable vegetation is sparse. The few individuals to be found are severely hedged and low in vigor. The major part of the cover is comprised of unpalatable perennials or of annuals, especially introduced species (fig. 48). Almost all young perennial plants are of low-quality species. Soil erosion is active, especially in years of unfavorable weather conditions for growth of annuals. Many of the plants are pedestaled. Much of the vegetation in the smaller drainages has been killed and the drainage channels are actively eroding.

4. **Ranges in very poor condition.** The desirable forage species have virtually disappeared. Dead crowns of grasses and stubs of desirable species are no longer present. The vegetation is dominated by undesirable perennials, with abundant annuals in the years when annuals grow. Soil erosion is severe, especially where adapted unpalatable shrubs did not replace the native perennials as they were destroyed (see discussion and figure 57 in section on "Recommended Grazing Management.") The soil is carried away by wind or water, leaving the plants pedestaled. The heavier particles of sand and silt are deposited in miniature dunes to the leeward of the vegetation. The finer particles of clay are carried great distances by the winds that sweep the valleys. When the vegetation is destroyed on the valley slopes and foothills, erosion along the drainage channels is increased. Such soil erosion is a two-way loss. The fine particles, which are richest in plant nutrients, are carried away; hence, the production of the range is reduced. Where the silt and sand are deposited, other vegetation is covered and destroyed. The raw disturbed areas are invaded by annuals or other undesirable forage species such as halogeton and Russian thistle. However, the cover they provide greatly retards soil loss.

By careful examination of the range, a manager can determine (1) areas in good condition, (2) areas in fair and poor conditions that can be improved through management, (3) areas in very poor condition where revegetation may be needed, and (4) areas where poisonous halogeton or other undesirable species are present.

On salt-desert shrub range, where the potential of sites and the successional stages of communities are so little understood, it is probably easier to judge trend in range condition than it is to recognize condition itself. Indicators of trend are the same and are recognizable across numerous sites or habitats. Expressing the direction and possibly the rate of ongoing change, trend indicates the effect—positive or negative—of the current livestock grazing practice and suggests permissible or necessary management actions to be taken for maintenance or improvement of range condition, whatever the status. If change is in progress, it is discernible by indicators.

Downward trend is indicated by a vigor of good forage plants that is visibly lower than that of unpalatable or less palatable associates. Palatable species show evidence of heavy or severe grazing use. Some plants have died in recent years and standing dead plants or their root stubs can be found. Younger plants of the desirable species are few as compared to the number of younger increaser or invader perennials. There is an obvious replacement of species in the direction of deteriorating forage quality.

Any signs of soil movement indicate downward trend. No matter how poor the condition, unstable soil signifies that it is becoming worse. Recent rilling on the gently sloping uplands between swales or depressions of natural drainage shows the soil surface to have lost its ability to transmit sheet flow from high-intensity rain showers. The natural gravel pavement or the algal mat has been trampled and broken to a degree of weakness that permits surface soil to be moved. Of equal or greater concern is evidence of wind erosion, scouring, and the formation of small dunes in the lee of plants.

Unlike signs of downward trend, indicators of upward trend are less frequently seen and less readily identifiable, so careful observation is necessary. For vegetation to change toward improvement of forage quality and quantity, there must be a weakening of established, long-lived undesirable plants so that new plants of desirable native species can return. Because there is no steady agent for improvement, succession toward a previous or more valuable community is often a slow and inconspicuous process. Occasionally some short-term, more or less catastrophic event such as severe drought or insect outbreak may drastically reduce undesirable perennials and open the community to establishment of seedlings. Replacement of individuals following such infrequent events results in many new plants of similar age. If there is still a seed source of the useful forage species, at least a part of the newer generation will be of those species, and the composition can ultimately improve. Some of the seedlings will be of the less valuable species, and it may take a number of selective reductions to allow substantial changes. Upward trend, then, is improvement in quantity and quality of vegetation provided that the soil is stable.

VEGETATION CHANGES AND EFFECTS OF LIVESTOCK GRAZING

Desert communities of perennial plants are not static. Their floristic composition may change dramatically over time. Such changes in relative amounts of the species components may be both cyclic (fluctuating) and unidirectional (trend). Superimposed on the compositional change is great variation from year to year in growth of all the vegetation—the sum of varying growth responses of individual species to specific conditions of different years.

The changes are attributable mainly to (1) climate, both short-term or seasonal weather conditions and cycles of several years, and (2) the selective removal of parts of some plants by animals, including insects. Occasionally some plants are destroyed by diseases. Different plants have inherent attributes that determine their reaction to the external factors, such as their innate longevity, palatability, resistance to defoliation, seeding habits, and adaptability to specific sites. With so many causes of vegetation change, range managers may find it difficult to judge what part of any change is due to their actions or is under their control.

Cyclic changes due to climate are primarily changes in relative productivity of the component species reflecting the pattern of precipitation in different years. Such change is short term. Another year may have different relative amounts of the same species. Occasionally, severe drought may materially reduce or eliminate a species from an area. This is change of a more permanent character, and it may or may not be reversible. Selective removal of species by drought has been observed a number of times at the Desert Experimental Range (DER). Hutchings (1954) cites severe reductions of shadscale in the droughts of 1933 to 1934 and 1942 to 1943. Similar reductions were again observed during the droughts of 1971 to 1972 and 1976 to 1977. Little rabbitbrush was apparently reduced by drought in the early 1950's (Ellison 1959). Both of these are increasers, considerably less valuable as forage plants and presumably less adapted to sites where they grew than are associated species, and both were on areas having a long history of abusive grazing. Neither shadscale nor rabbitbrush should have been abundant except for the grazing history, and as Ellison (1959) suggests for rabbitbrush, the increaser is less efficient than the desirable species component in occupying that site.

Perennial plants of some species are comparatively long lived. In the Great Basin, for example, individuals of winterfat, black sagebrush, and sand dropseed, once they are established, may persist for several decades. Other perennials have considerably shorter normal life spans: globemallow only a few years, Indian ricegrass about a decade or two at most, shadscale somewhat longer. Budsage and little rabbitbrush are moderately long lived. Mortality, whenever it occurs, is more likely due to a combination of factors or conditions than to a single cause. But some loss of individual plants, such as that from undermining and severing of roots by pocket gophers, is direct and readily understood. The drought-related losses of shadscale mentioned above may have resulted simply from insufficient moisture or, perhaps more likely, the extreme dryness operating together with insects. Severe reductions of shadscale populations have been described as caused by a snout moth (Hutchings 1952) and a scale insect (Sharp and Sanders 1978), both in southern Idaho. However, insect status was not observed during the four 2-year drought periods when shadscale losses were heavy. Indian ricegrass in 1972, the second year of a drought at the DER, was totally eliminated from large areas by a combined effect of the drought and insect larvae inhabiting the basal thatch of the bunchgrass (Guerra 1973). Very few innovations (tillers) sprouted in the early spring from the bunches, and the insect numbers were sufficient to destroy all of them before they emerged above ground.

Diseases of unknown cause occasionally reduce the densities of some species. This is a rather common occurrence in budsage, where certain size or age classes appear to be more susceptible to attack than others.

As has been described, mortality of individuals or reduction in their productivity can be abrupt and severe or more gradual. In either case, reduction of certain species in the community is but one side of the process of compositional change. The aspect of new plant establishment is another. West and others (1979) concluded that new plant establishment in the perennial cover of the desert largely depends on the opportunity of space made available by the death of other plants. This appears to be true if those perennial plants already there are vigorous individuals of species well adapted to the site rather than opportunistic invaders or increasers (Ellison 1959).

Removal of shoot material of living plants by grazing or clipping weakens them to some degree, depending upon severity of pruning and stage of growth when it occurs. Some photosynthetic material and stored carbohydrate reserves needed for growth, reproduction, and maintenance of vigor are lost. Cook and his coworkers (Cook 1971; Cook and Child 1971) found the effects of top removal at certain seasons and intensities persisted for 7 years after the treatment ceased on desert shrubs and grasses. Generally, only the plants clipped at the lightest rates or during dormant seasons showed full recovery during that time. A number of plants subjected to the most severe treatments died.

Sheep grazing studies at the DER since 1935 have produced a wealth of information on effects of grazing on salt-desert shrub vegetation (Hutchings and Stewart 1953). Large range pastures were grazed at one of three intensities (light, moderate, or heavy) and one of three winter seasons (early, middle, or late). Because the last season did not end until early April, it could properly be described as early spring. Records were maintained of precipitation, herbage production, and forage use. Herbage production was closely correlated with annual precipitation ($r=0.944$).

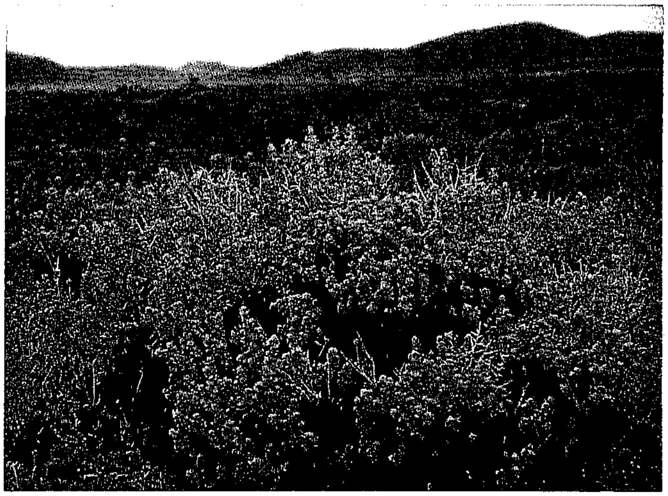


Figure 3.—*Atriplex canescens* (fourwing saltbush).

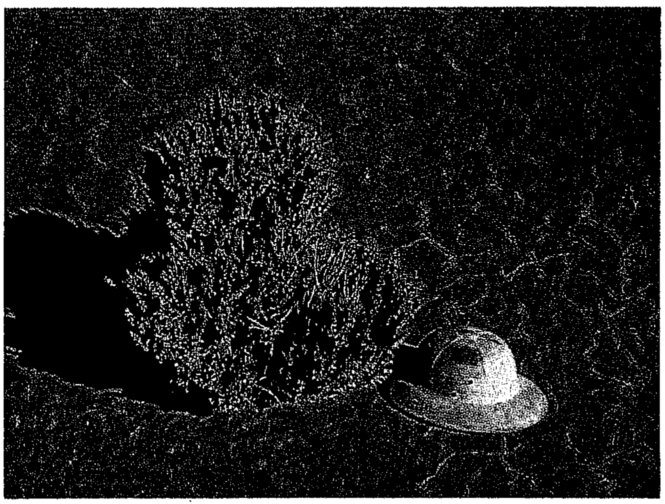


Figure 4.—*Atriplex confertifolia* (shadscale) on the playa at the Desert Experimental Range (DER) in southwestern Utah.

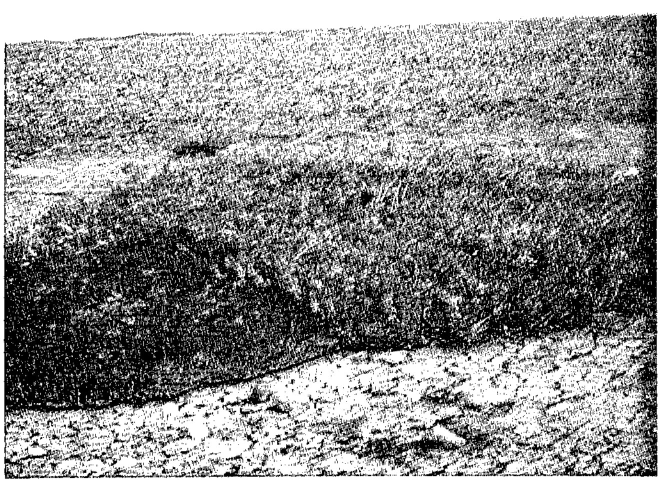


Figure 5.—*Atriplex corrugata* (mat saltbush) (left) and *Atriplex cuneata* (Castle Valley clover) (right) near Fremont Junction in central Utah.

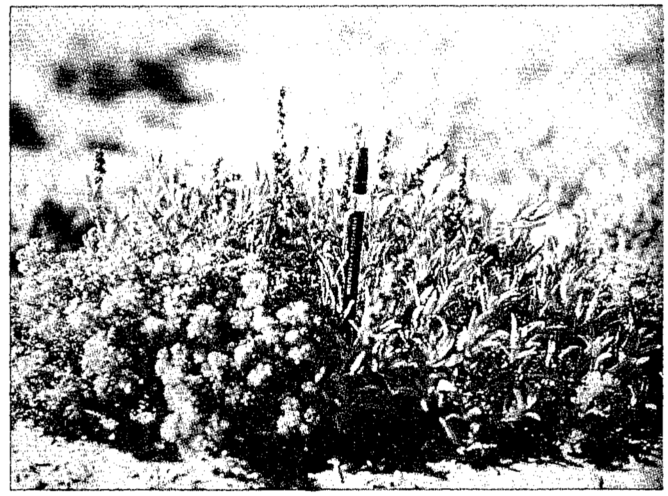


Figure 6.—*Atriplex gardneri* (Gardner saltbush) growing in the Red Desert, Wyoming. Notice the budsage in the lower left portion of the clump.

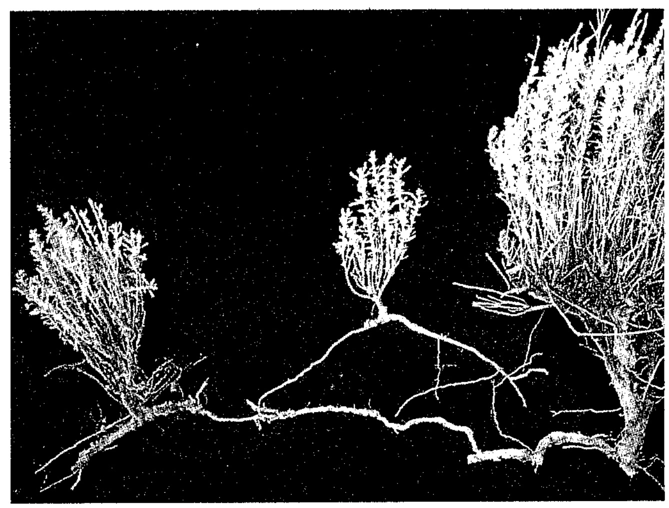


Figure 7.—*Atriplex tridentata* (saltsage) showing the root-sprouting character.

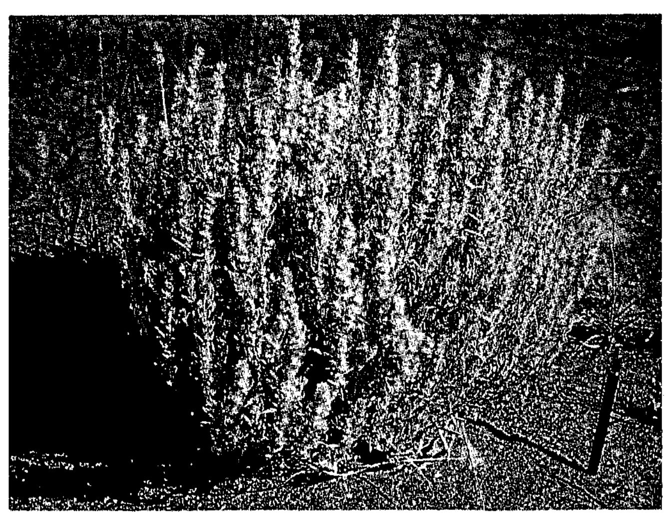


Figure 8.—*Ceratoides lanata* (winterfat).

Figure 9.—*Grayia spinosa* (spiny hopsage).

Figure 10.—*Kochia americana* ssp. *vestita* (gray molly).

Figure 11.—*Sarcobatus vermiculatus* (black greasewood).

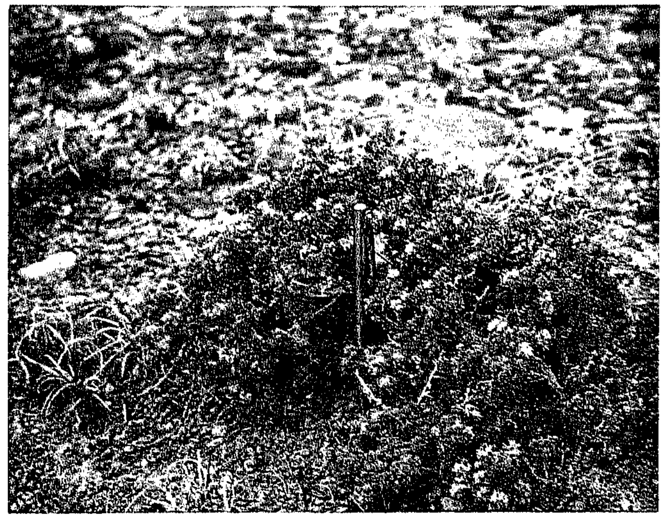


Figure 12.—*Artemisia spinescens* (budsage) growing near Sevier Lake in western Utah.

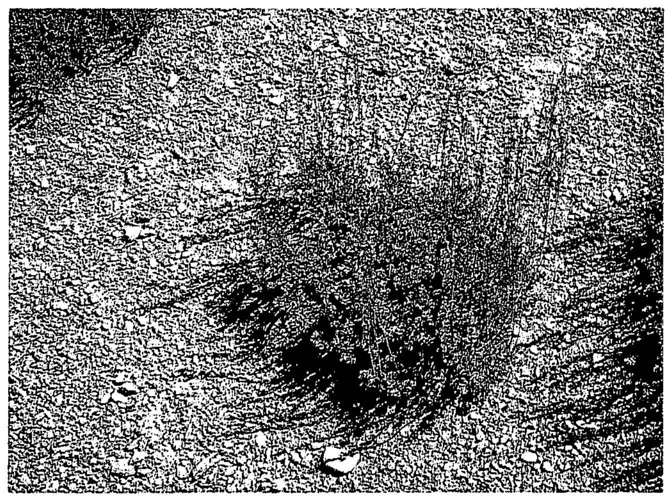


Figure 13.—*Artemisia nova* (black sagebrush).

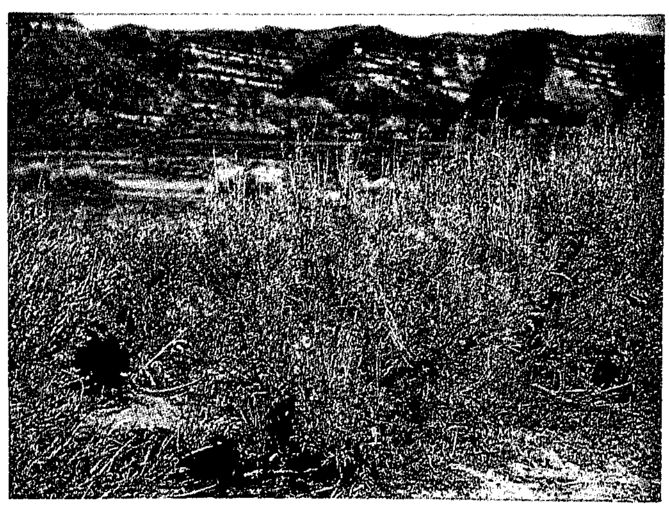


Figure 14.—*Artemisia tridentata* ssp. *tridentata* (basin big sagebrush) at Gordon Creek near Helper, Utah.

Figure 15.—*Chrysothamnus viscidiflorus* ssp. *axillaris* (low rabbitbrush) in Antelope Valley near the Desert Experimental Range.

Figure 16.—*Hilaria jamesii* (galleta).

Figure 17.—*Sporobolus cryptandrus* (sand dropseed).

Figure 18.—*Sporobolus airoides* (alkali sacaton) in Snake Valley, Millard County, Utah.

Figure 19.—*Bouteloua gracilis* (blue grama).

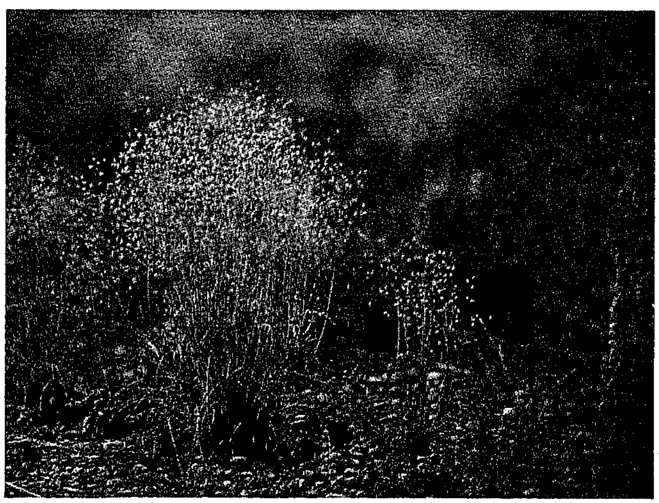


Figure 20.—*Oryzopsis hymenoides* (Indian ricegrass) in Snake Valley, Millard County, Utah.

Figure 21.—*Sitanion hystrix* (bottlebrush squirreltail) growing on a productive site.

Figure 22.—*Sphaeralcea grossulariaefolia* (gooseberryleaf globemallow) in the Ferguson Desert north of the Desert Experimental Range.

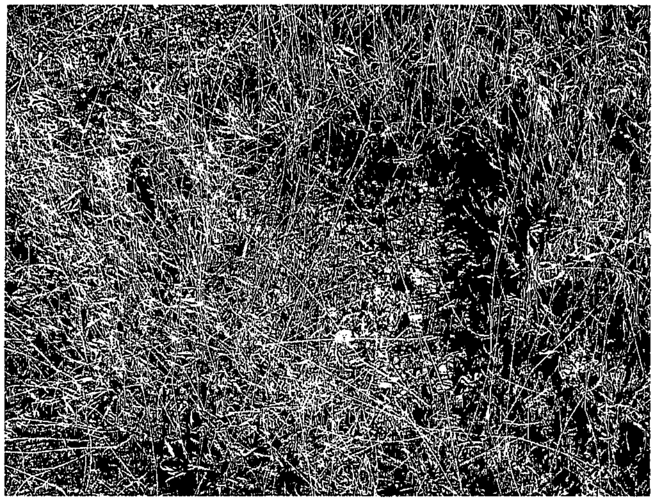


Figure 23.—*Bromus tectorum* (cheatgrass).

Figure 24.—*Salsola iberica* (Russian thistle) (right) and *Halogeton glomeratus* (halogeton) (left) growing near Malta, Idaho.

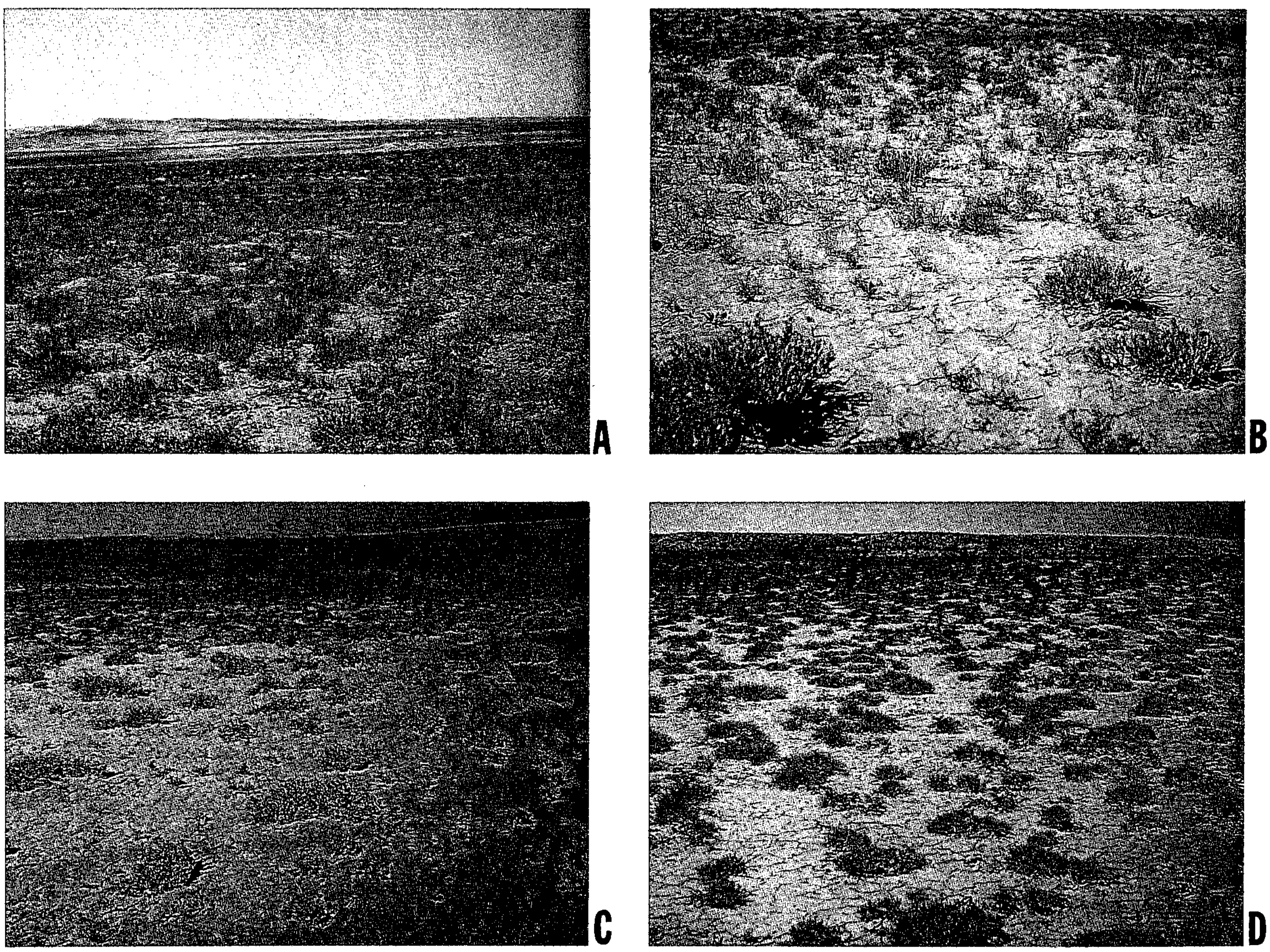


Figure 25.—Four salt-desert shrub habitat types near Cisco, Grand County, Utah, described by West and Ibrahim (1968).
A. *Atriplex confertifolia—Hilaria jamesii* h.t.
B. *Atriplex tridentata—Hilaria jamesii* h.t.
C. *Atriplex gardneri—Aster xylorhiza* h.t.
D. *Atriplex corrugata* h.t.

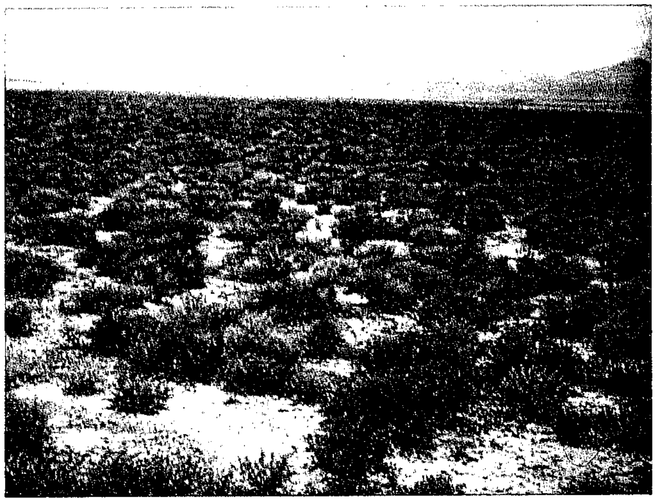


Figure 26.—A shadscale community in Pine Valley, southwestern Utah.

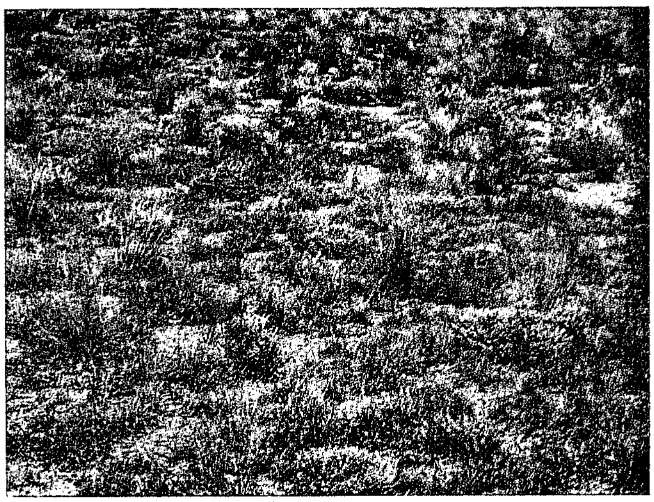


Figure 27.—A shadscale-winterfat-galleta-Indian ricegrass community on the Desert Experimental Range.

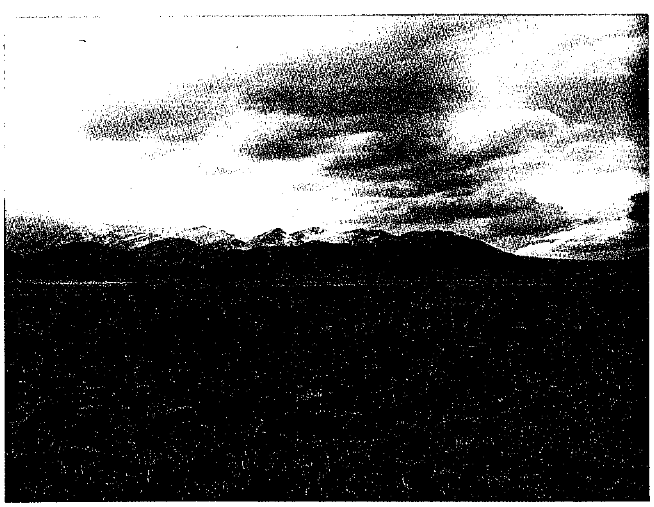


Figure 28.—A shadscale-sand dropseed community in Pine Valley, Utah.

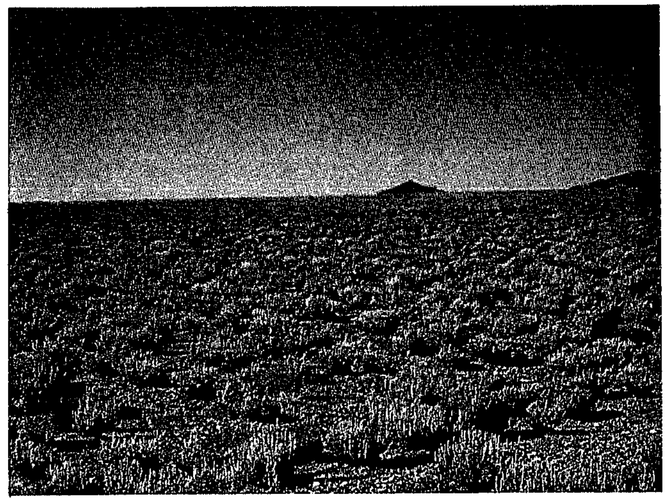


Figure 29.—Winterfat community in the research natural area at the Desert Experimental Range.

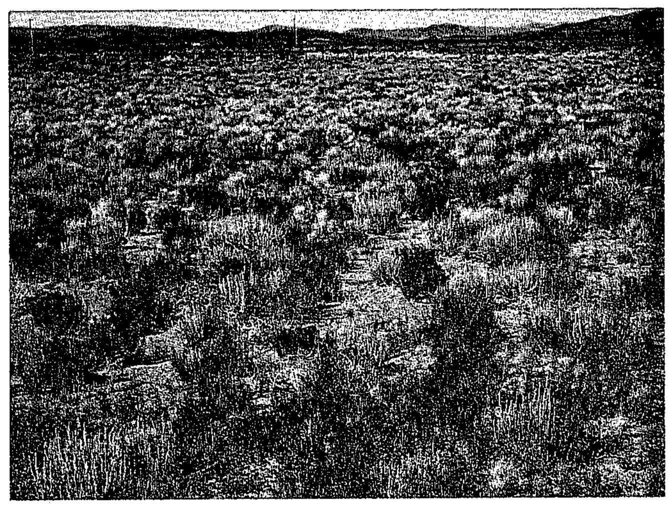


Figure 30.—A winterfat-low rabbitbrush-Indian ricegrass community in Mason Valley, Lyon County, Nev.

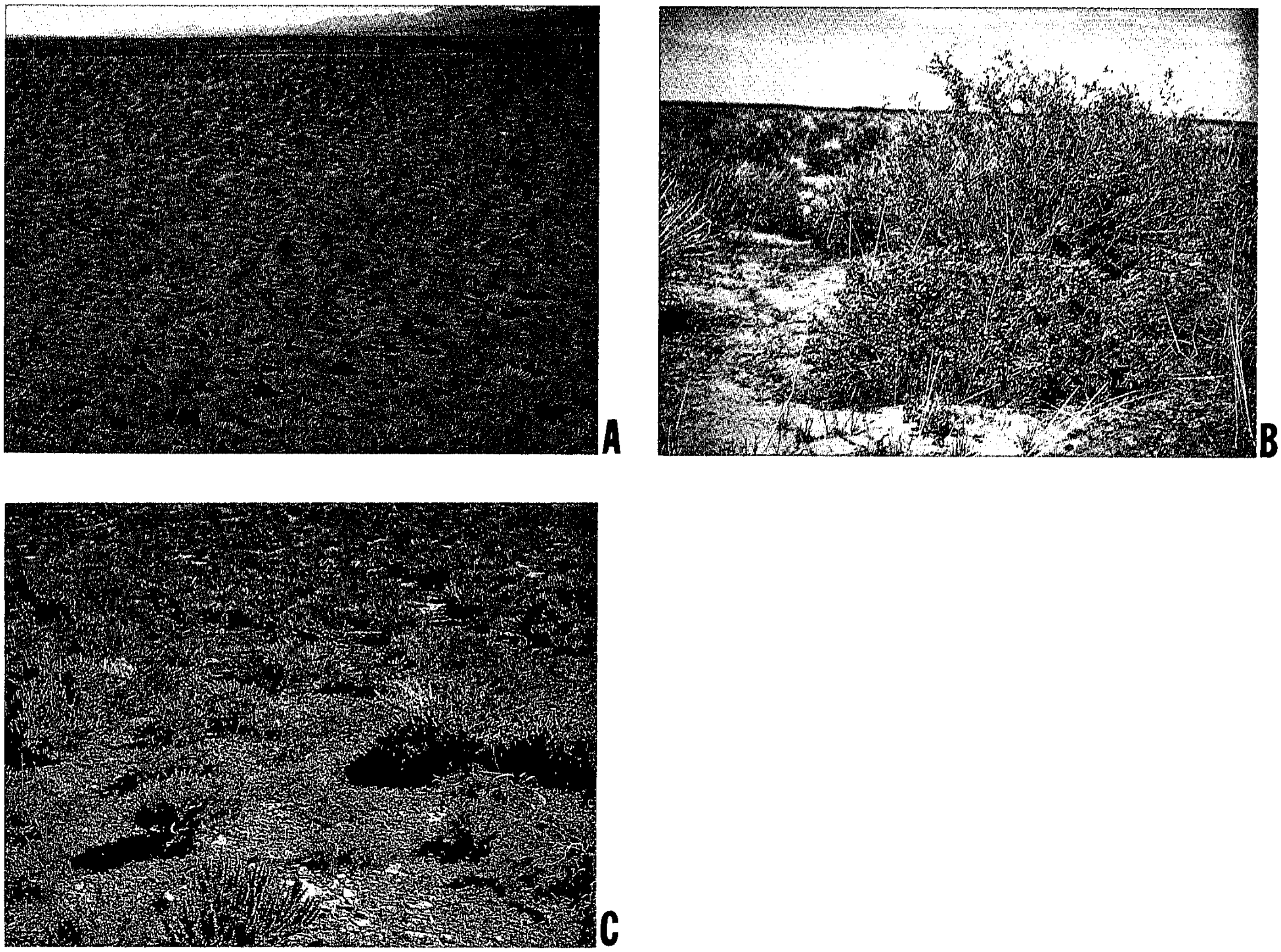


Figure 31.—Budsage growing in mixtures with (A) winterfat and ricegrass in Pine Valley, Utah, (B) spiny hopsage near Rome, Oreg., and (C) shadscale in Humboldt County, Nev.

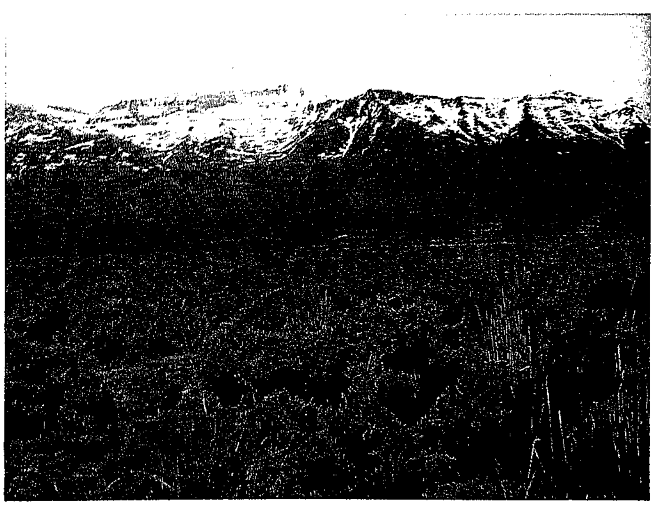


Figure 32.—A greasewood-Great Basin wildrye (*Elymus cinereus*) community in Elko County, Nev.

Figure 33.—A greasewood-shadscale community south of Delta, Utah.

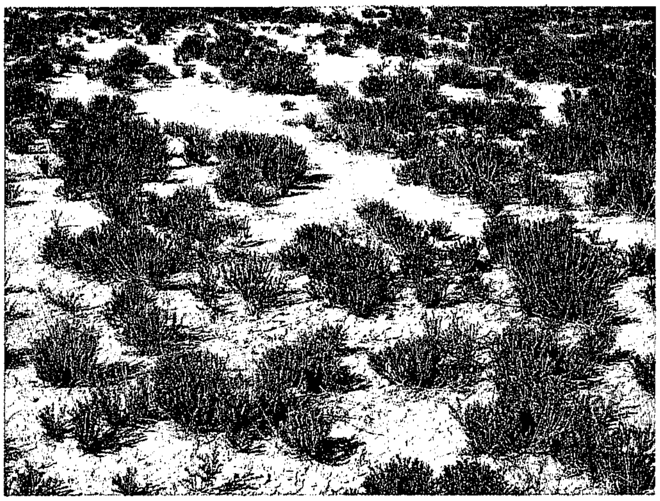


Figure 34.—Gray molly community in Ferguson Desert north of Desert Experimental Range.

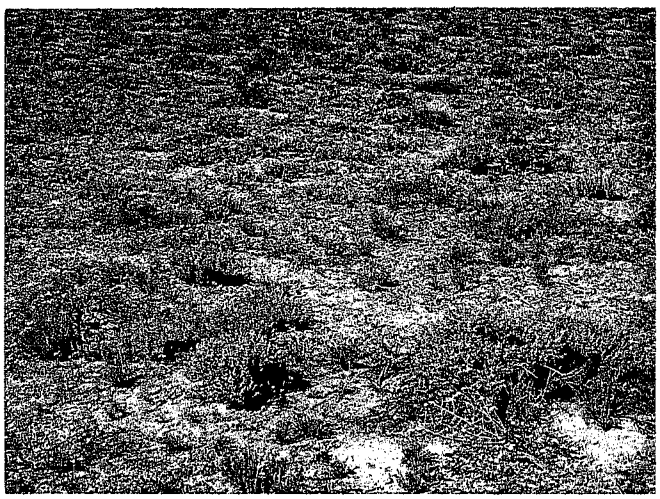


Figure 35.—Gray molly-shadscale-budsage-winterfat community in the Ferguson Desert.

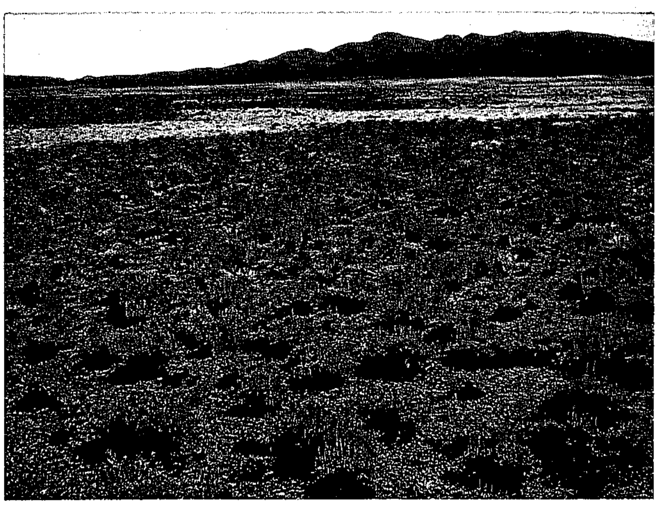


Figure 36.—A black sagebrush community.

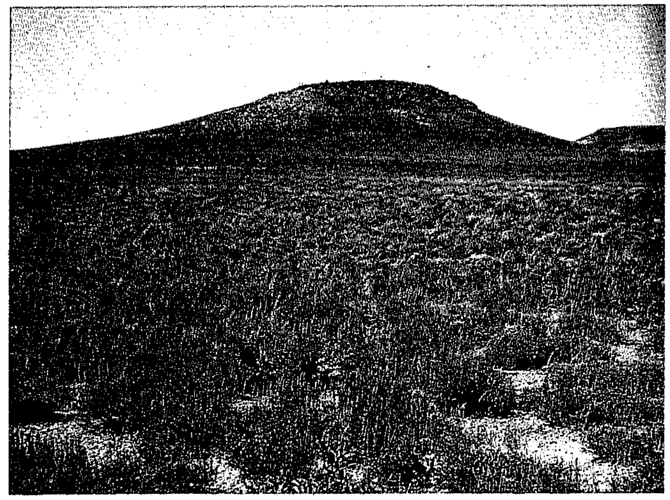


Figure 37.—Black sagebrush-shadscale-grass northwest of Cedar City, Utah.

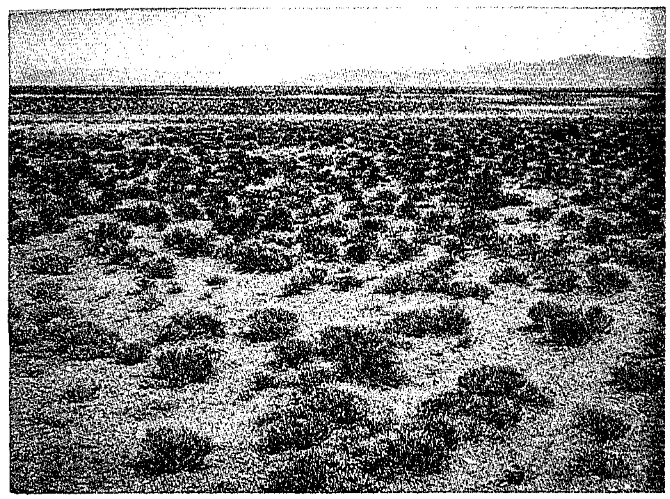


Figure 38.—A low rabbitbrush community in southwestern Utah.

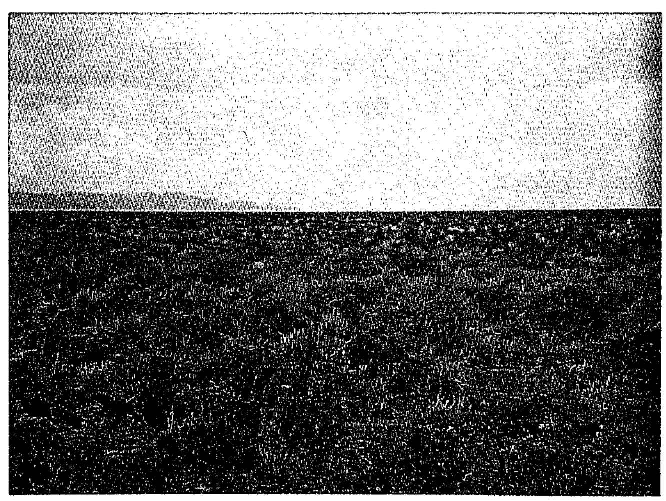


Figure 39.—Low rabbitbrush-winterfat-grass community in Delamar Valley, Nev.

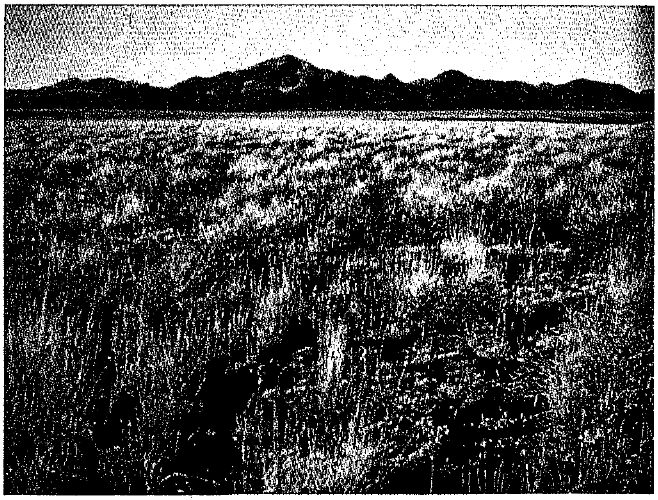


Figure 40.—A spiny hopsage-galleta community in Pine Valley, Utah.

Figure 41.—A fourwing saltbush-Indian ricegrass community.

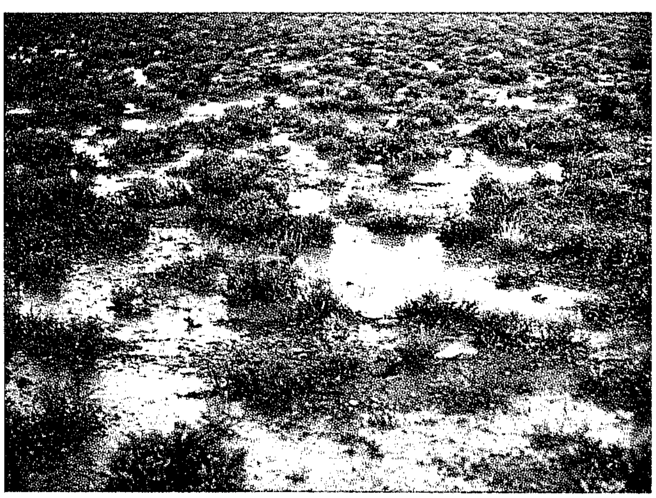
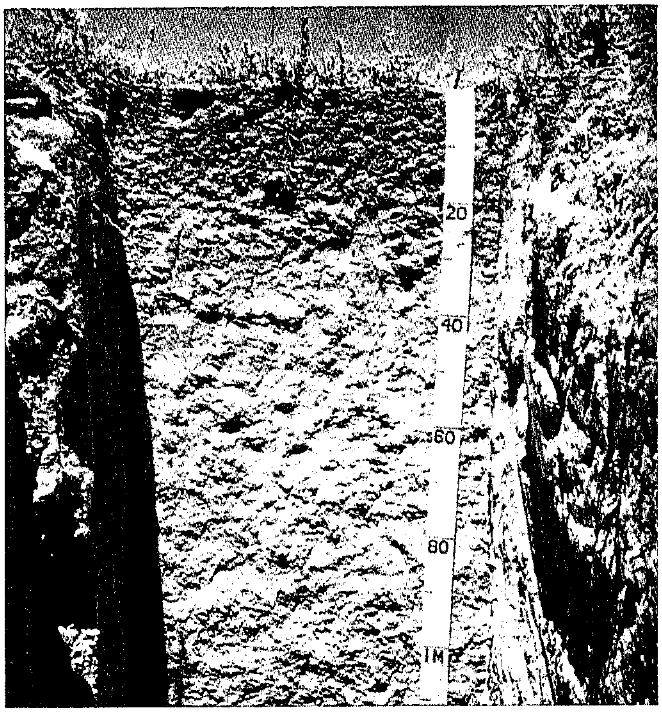
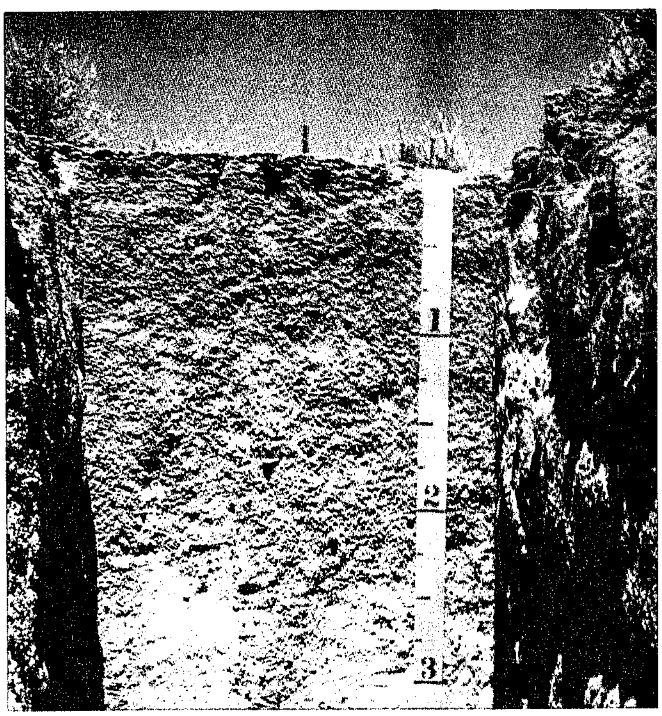


Figure 42.—Surface water accumulation at the Desert Experimental Range as a result of a storm that deposited 0.4 inch (1 cm) during 14 minutes on July 23, 1969.



A

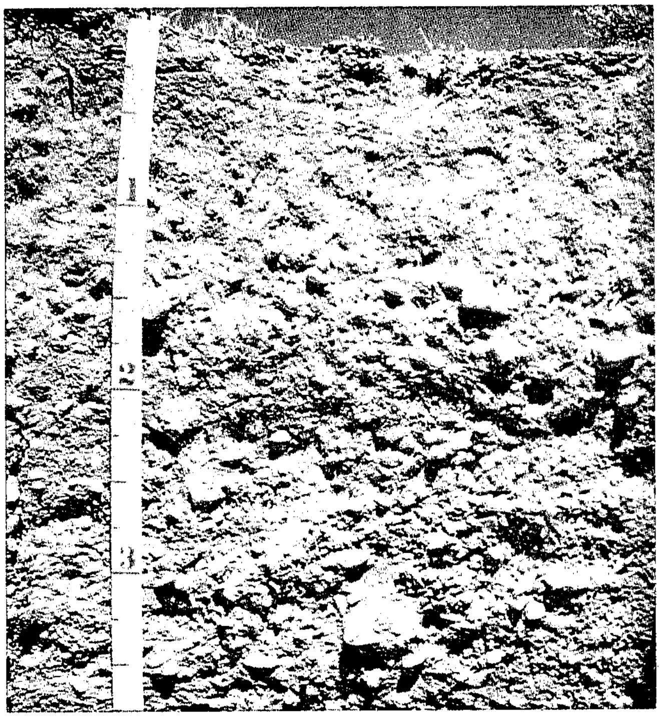
A



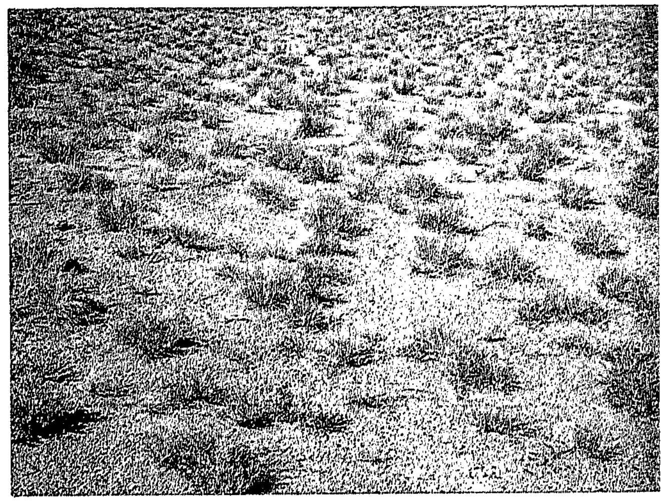
B

B

Figure 43.—Similar stands of winterfat supported by three different soils.
A. Silt loam (Torrifluvent)
B. Sandy loam (Calciorthid)
C. Gravelly sandy loam (Camborthid)
Compare with fig. 44B, gravelly sandy loam (Paleorthid).



C



C

Figure 43. (con.)

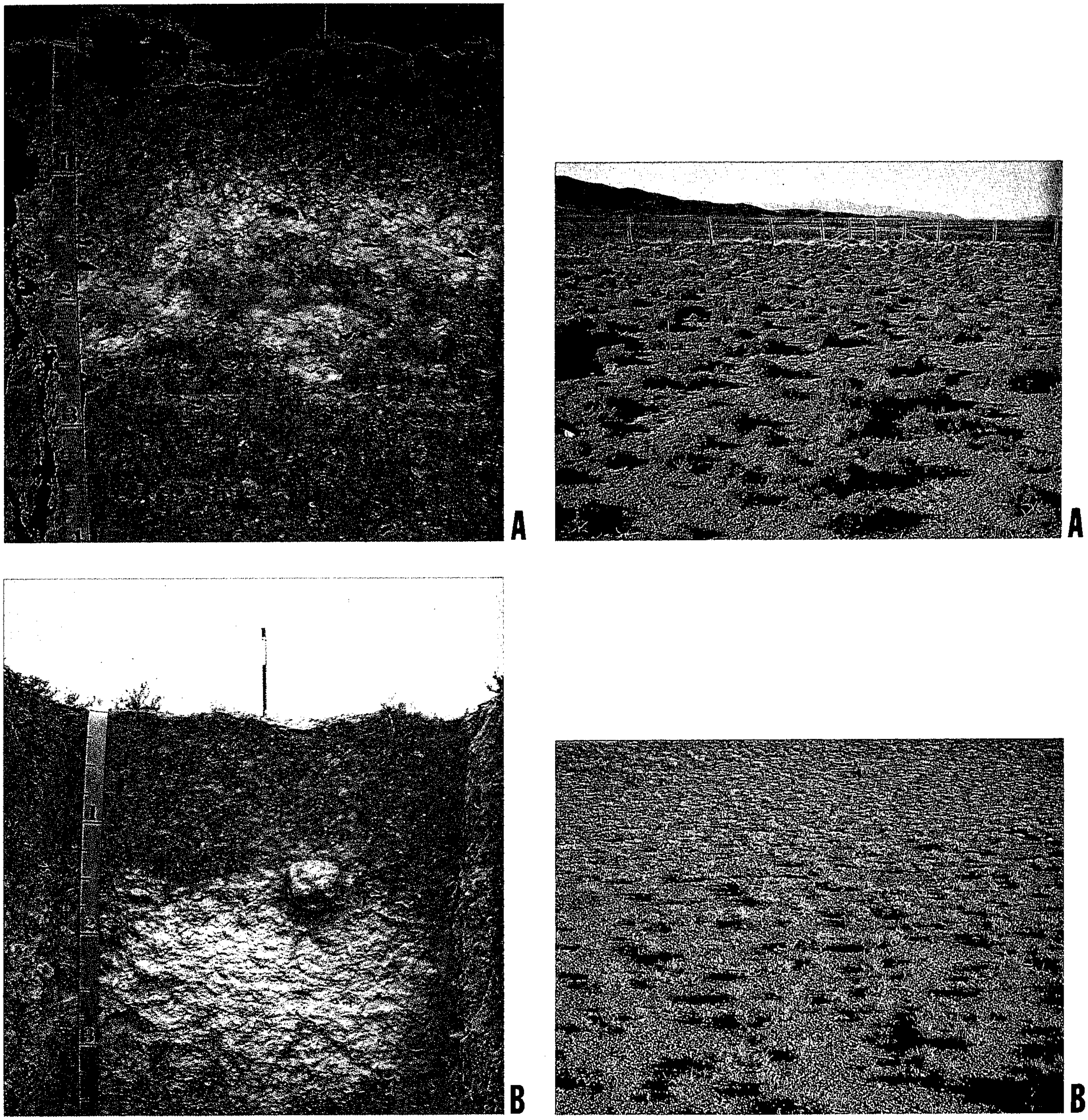
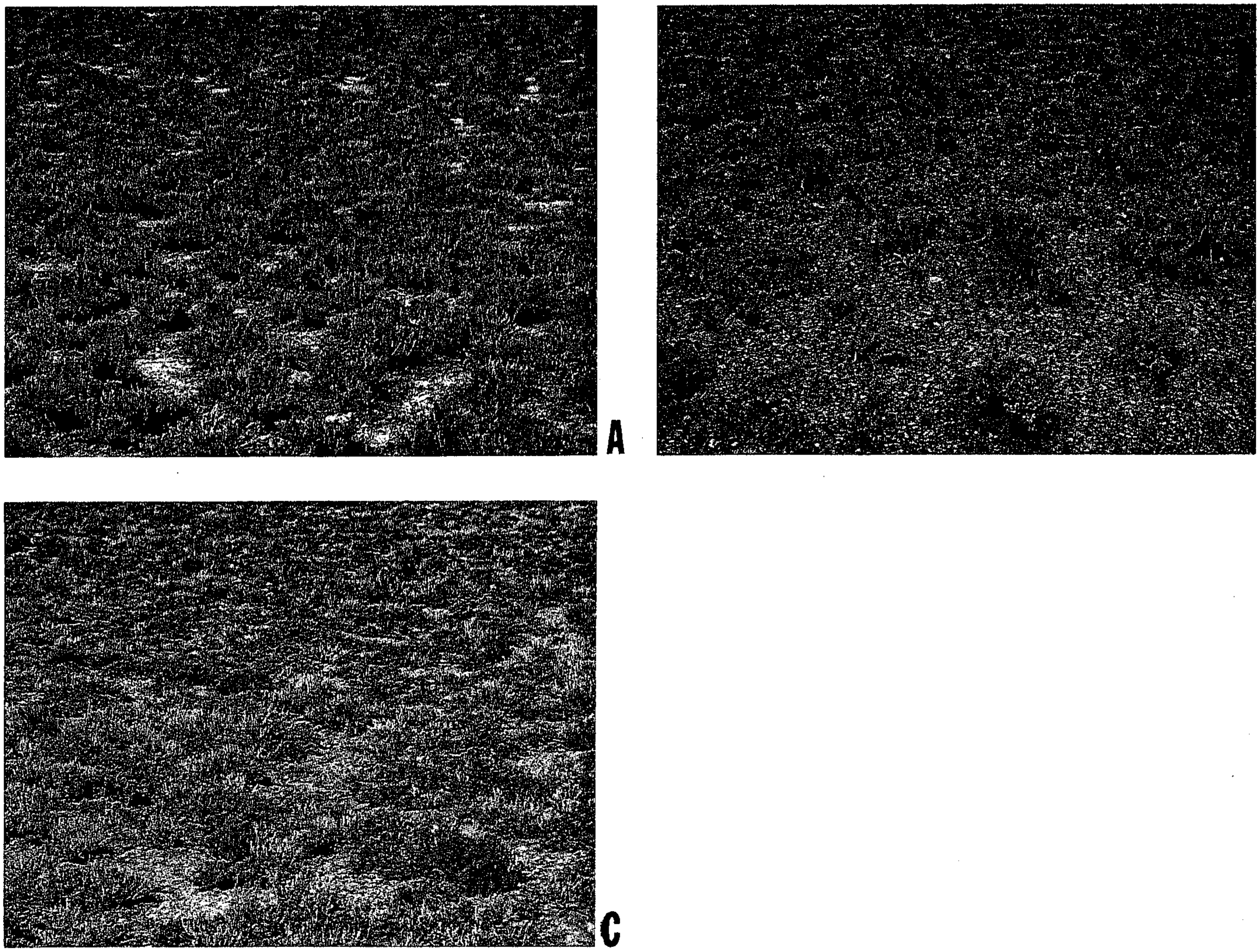
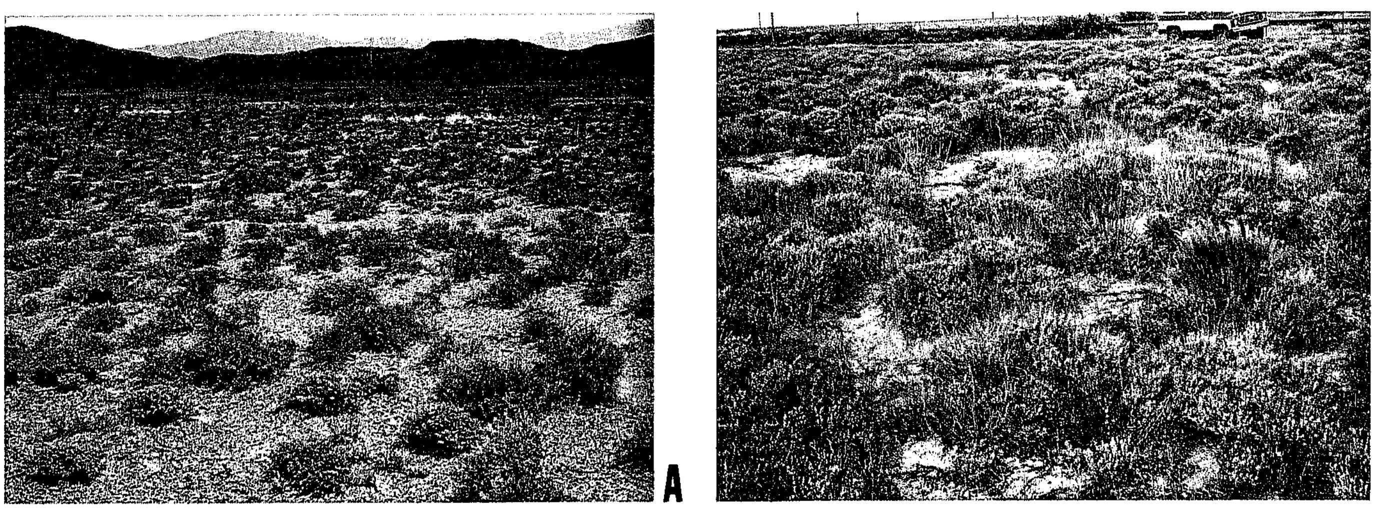


Figure 44.—A. Black sagebrush sommunity and corresponding soil profile in gravelly sandy loam of the Calciorthid great group. B. Adjacent winterfat community and soil profile in gravelly sandy loam of the Paleorthid great group.



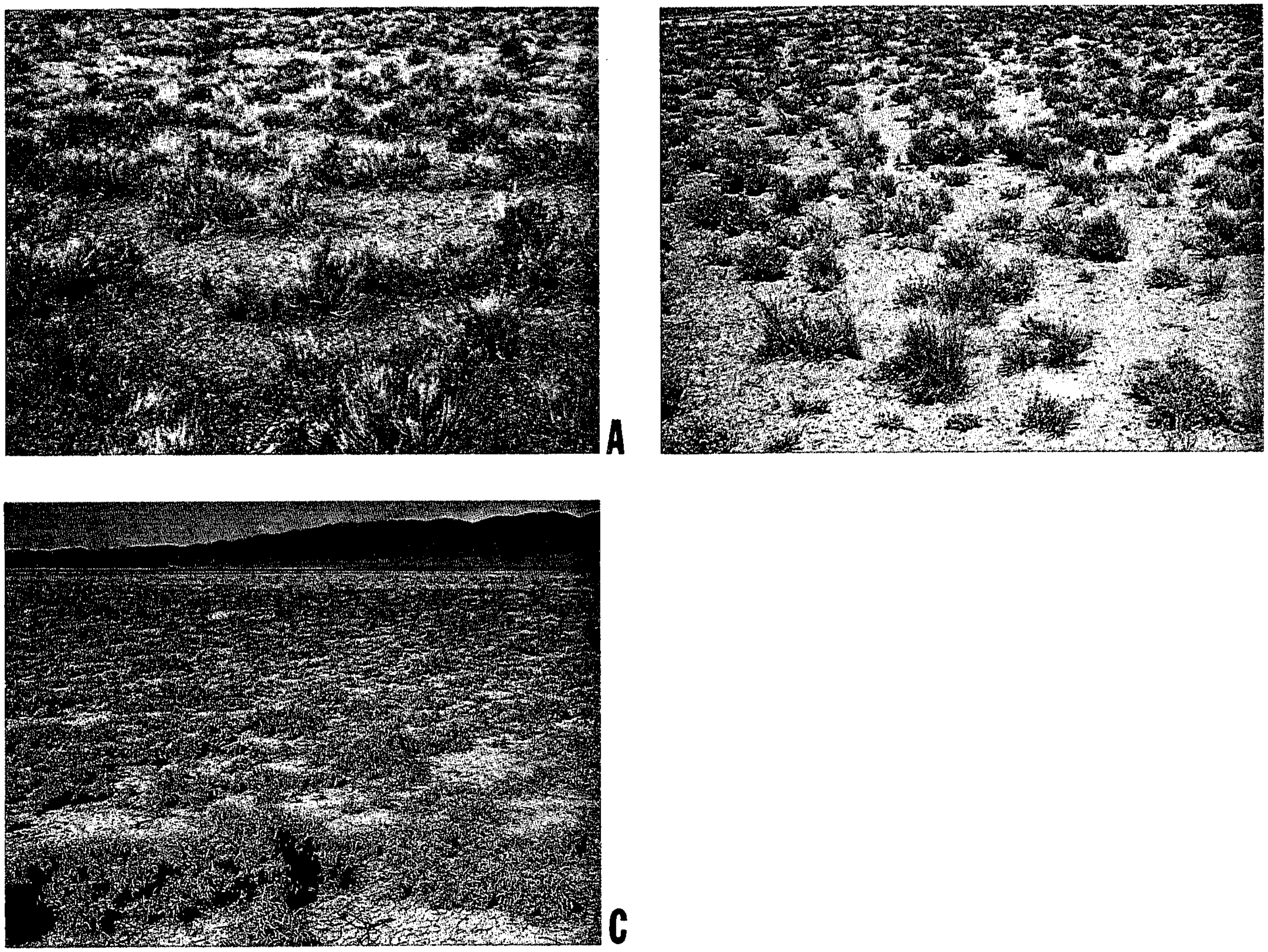
A B C

Figure 45.—Good condition salt-desert shrub ranges dominated by desirable species. A. Winterfat community on Desert Experimental Range. B. Winterfat-budsage community in Antelope Valley, Utah. C. Black sagebrush-winterfat community in eastern Nevada.



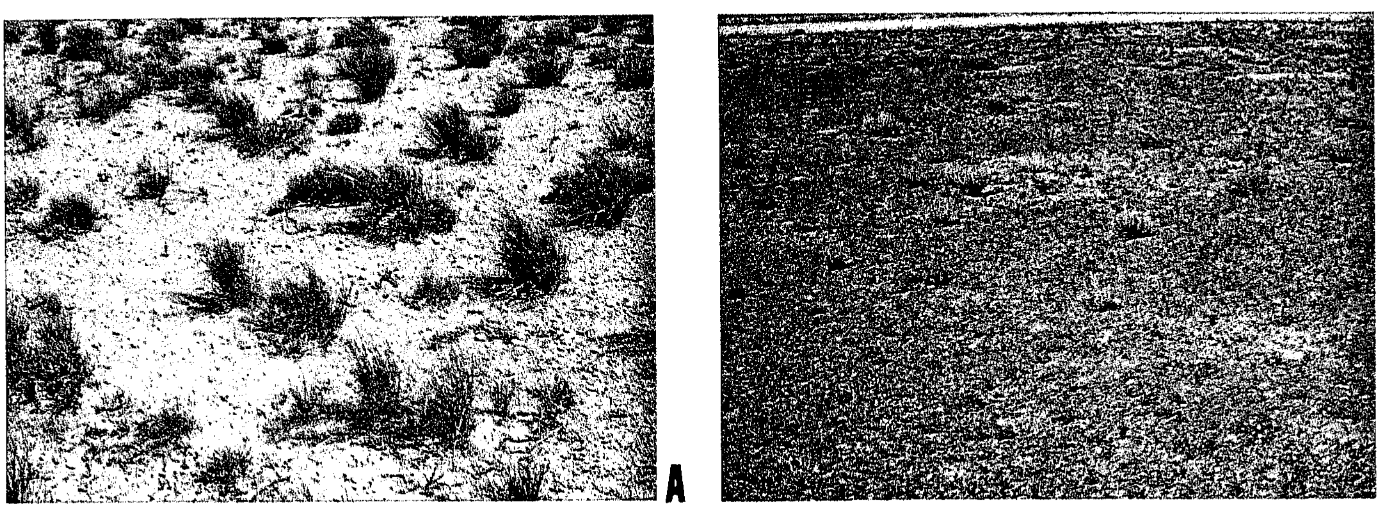
A B

Figure 46.—Good condition salt-desert shrub ranges dominated by less desirable species.
A. Low rabbitbrush-black sagebrush, winterfat-grass community in Antelope Valley, Utah. B. Shadscale-squirreltail-ricegrass community south of Delta, Utah.



A B C

Figure 47.—Fair condition salt-desert shrub ranges in southwestern Utah.
A. Low rabbitbrush-winterfat-Indian ricegrass community in Wah Wah Valley.
B. Winterfat-shadscale-ricegrass community on the Desert Experimental Range. C. Galleta-shadscale community in Wah Wah Valley.



A B

Figure 48.—Poor condition salt-desert shrub ranges.
A. Indian ricegrass-sand dropseed, with a scattering of shadscale and winterfat on the Desert Experimental Range. Note good production of forage grasses. B. Sparse stand of winterfat-budsage-annuals in the Ferguson Desert.

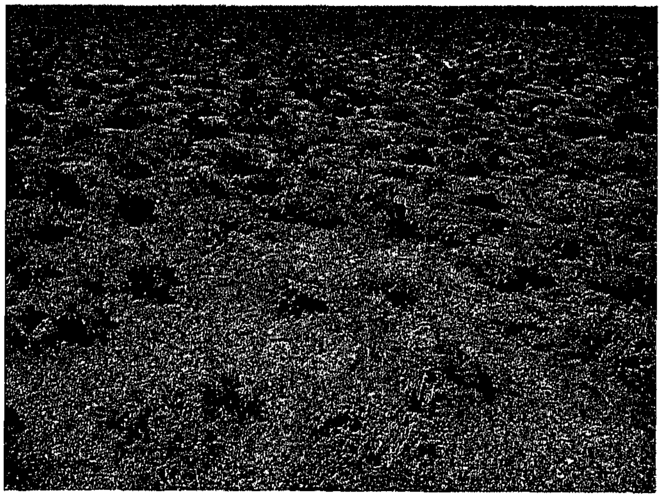


Figure 51.—*Black sagebrush, has increased* greatly, while low rabbitbrush has largely disappeared as a result of a change from heavy to moderate grazing.

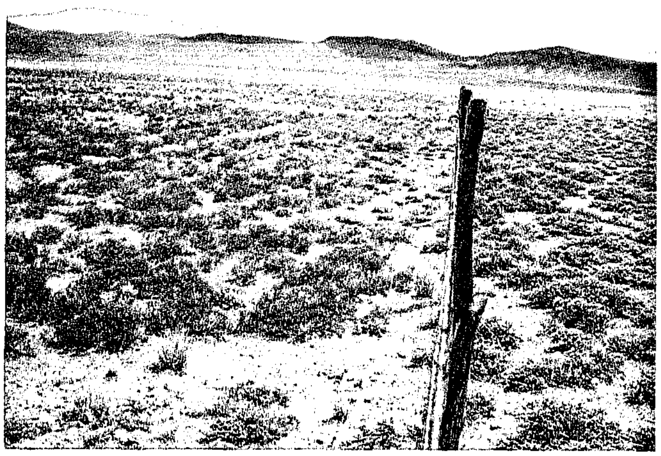


Figure 52.—Area on the right side of the fence has been grazed at a moderate rate and is now dominated by black sagebrush. Grazing on the left has been continued at a heavy rate and low rabbitbrush still dominates the site.

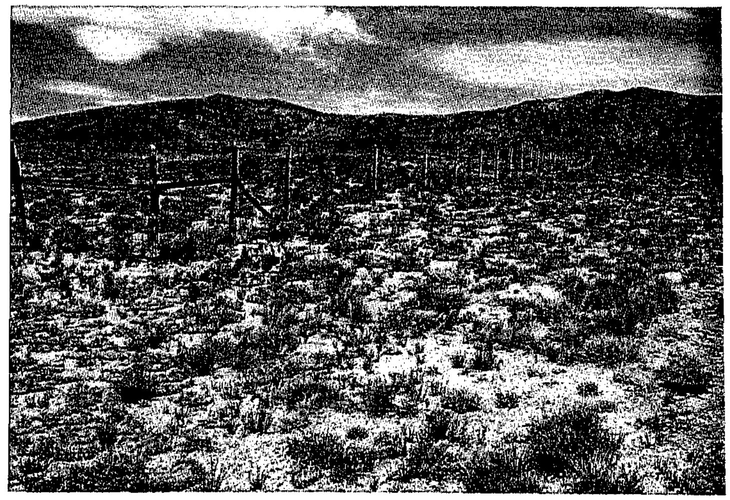


*Figure 53.—Black sagebrush, a minor com*ponent of the vegetation when the exclosure was fenced in 1937, has been unable to make a comeback under moderate year-after-*year grazing by sheep in midwinter or late* winter. Note the good stand of black sagebrush in the ungrazed exclosure.

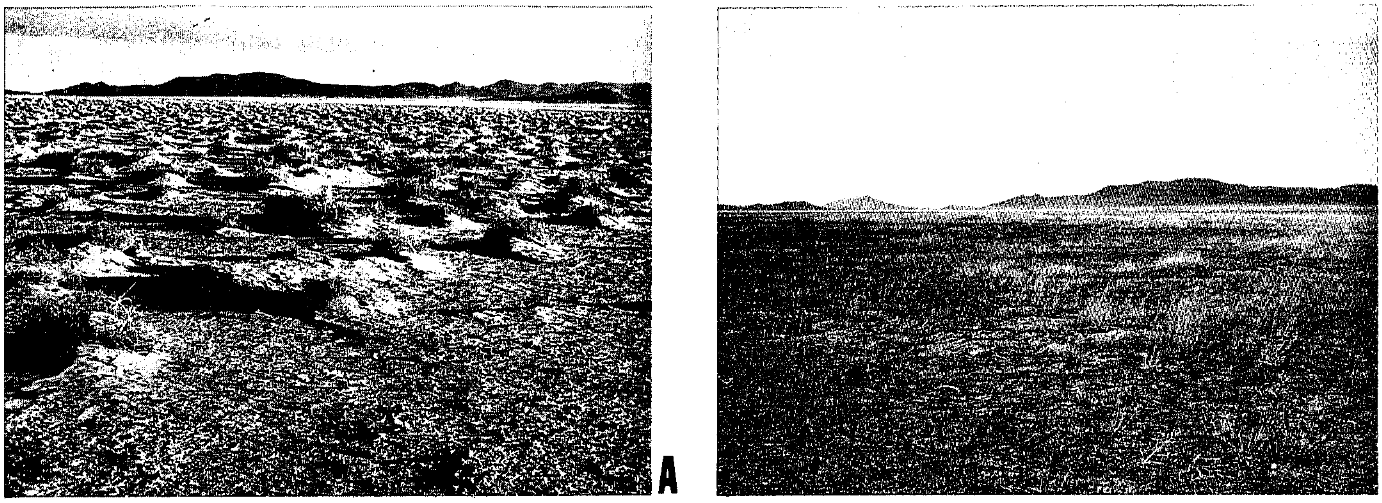

A
B

Figure 57.—Photos of the same area in Wah Wah Valley, 1935 and 1982. Since lowering the stocking rate and removal of livestock during the summer, this area of incipient dunes has stabilized. It is still in very poor condition, lacking in high-quality forage species, with the soil largely held in place by annuals.

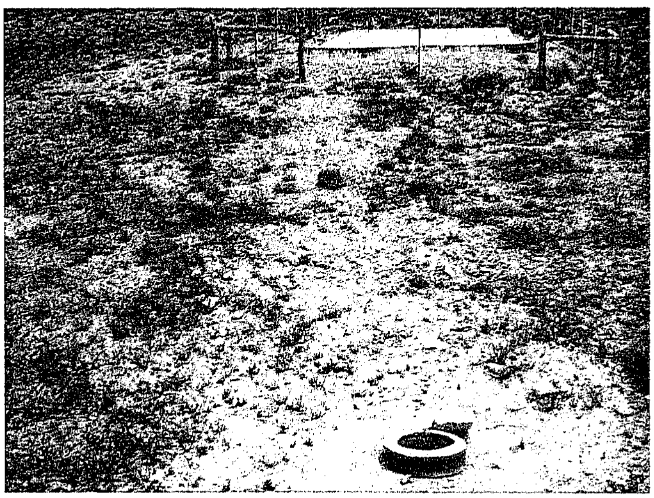


Figure 60.—Typical "guzzler" for wildlife with collecting apron, storage tank, drinking fountain, and float valve.

Intensity of Grazing

In studies at the DER, the desired intensity of grazing in each pasture was obtained by varying the number of sheep. Stocking rates were adjusted each year on the basis of herbage yields measured in October. This was done so that forage use from year to year would be fairly uniform. Average stocking rates were 10, 14, and 17 sheep days per acre (25, 35, and 43 sheep days/ha) for light, moderate, and heavy grazing, respectively.

Under heavy grazing, the desirable forage species were closely used and often seriously injured or killed. For example, winterfat, an abundant and palatable species, was reduced to less than half its original yield during 28 years of heavy grazing in late winter (Holmgren and Hutchings 1972). In other studies, when trends were adjusted for differences in precipitation, winterfat production under light and moderate grazing during a 13-year study was more than doubled. Under heavy grazing, its production did not improve (fig. 49).

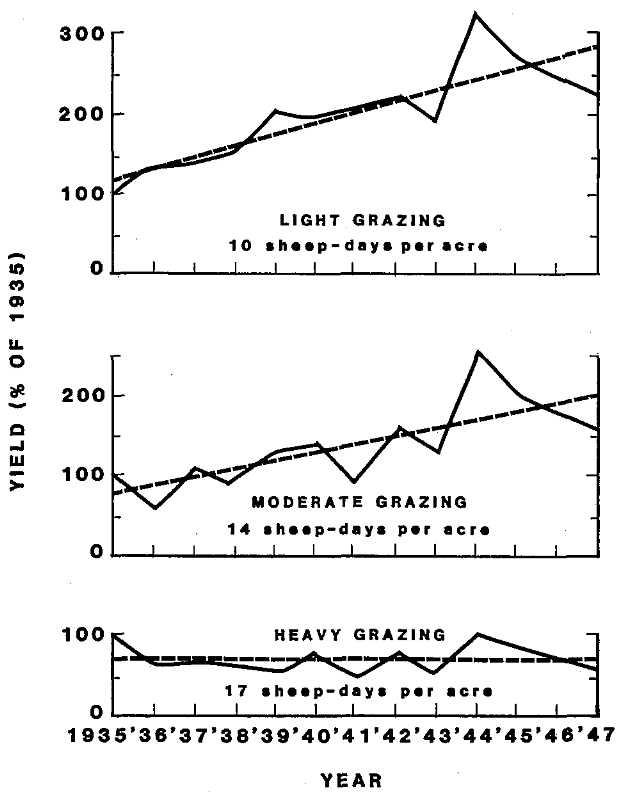


Figure 49.—Trends in production of winterfat under heavy, moderate, and light grazing by sheep in winter at the Desert Experimental Range (from Hutchings 1966a)

In another area on the DER, moderate grazing at 15 sheep days per acre (38 sheep days/ha) allowed substantial increases in such desirable species as black sagebrush and winterfat accompanied by a decrease in such undesirables as low rabbitbrush. Conversely, heavy grazing at more than 25 sheep days per acre (62 sheep days/ha) caused a decrease in the desirable species and an increase in the undesirables (fig. 50).

In addition to rate of stocking, Hutchings and Stewart (1953) found that actual degree of grazing use for a particular forage species was related to other factors, including level of palatability and abundance. Use of a palatable species was very heavy if it constituted less than 10 percent of the total yield of the vegetation even in pastures stocked at the moderate rate with sheep. The animals seek out the palatable species first, going to the less palatable later. When a desirable species is in short supply, it is sure to be severely used, even under a light stocking rate on an area basis. Less palatable species are also taken to a greater degree where they make up a small proportion of the total vegetation than where they are abundant. In such situations, sheep days per acre is not a satisfactory measure of grazing intensity. Actual degree of use for particular species should be observed.

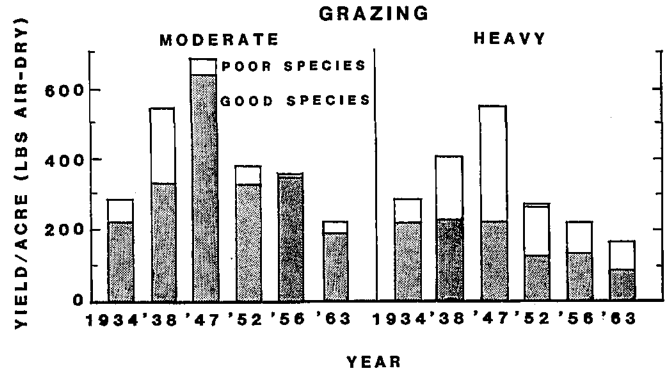


Figure 50.—Effects of moderate and heavy grazing on relative amounts of desirable and undesirable species (after Hutchings 1966a).

On deteriorated ranges where desirable species are poorly represented, their recovery is especially difficult. This is illustrated by response of black sagebrush in the large allotments on the DER, where it was only a minor element in the plant cover in all but 2 of the 12 sheep allotments. In these two, it increased severalfold on the sites where it originally occurred as a result of reduced grazing pressure during the beginning years of the study (fig. 51). These allotments now provide more sheep days of use than they did 40 years age, and black sagebrush continues to increase at the expense of low rabbitbrush (fig. 52). In eight of the other allotments where black sagebrush was much less abundant, it has not recovered to its potential (fig. 53). These areas are moderately grazed every year, two in the cold part of winter, two in the late winter, and four alternately used in winter and late winter.

Season of Grazing

The effect of season of grazing did not become apparent at DER during the first dozen years, and so was not reported by Hutchings and Stewart (1953). After more than 30 years of treatment, however, the most striking differences in vegetation resulted from season of use. For example, Holmgren and Hutchings (1972) reported that under heavy grazing in early winter the desirable winterfat and budsage, the moderately desirable grasses, and the undesirable shadscale all increased. At the same intensity of use in late winter, winterfat and budsage suffered substantial losses, grass remained about constant, and shadscale increased markedly (fig. 54).

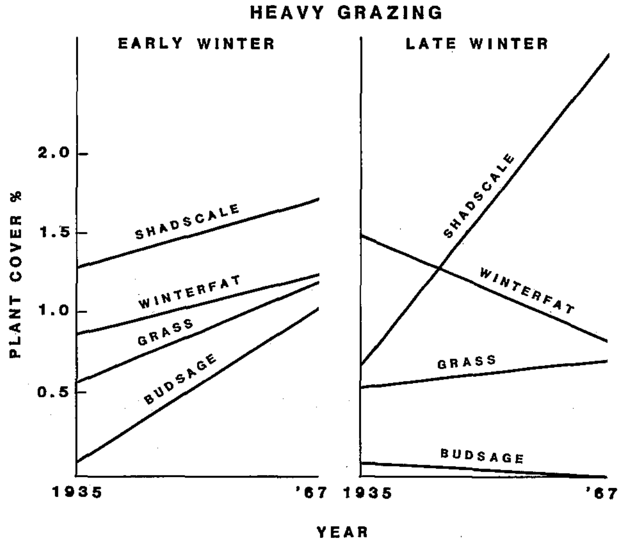


Figure 54.—Plant cover trends for species grazed by sheep at a heavy stocking rate in early winter (left) and late winter (right) at the Desert Experimental Range (after Holmgren and Hutchings 1972).

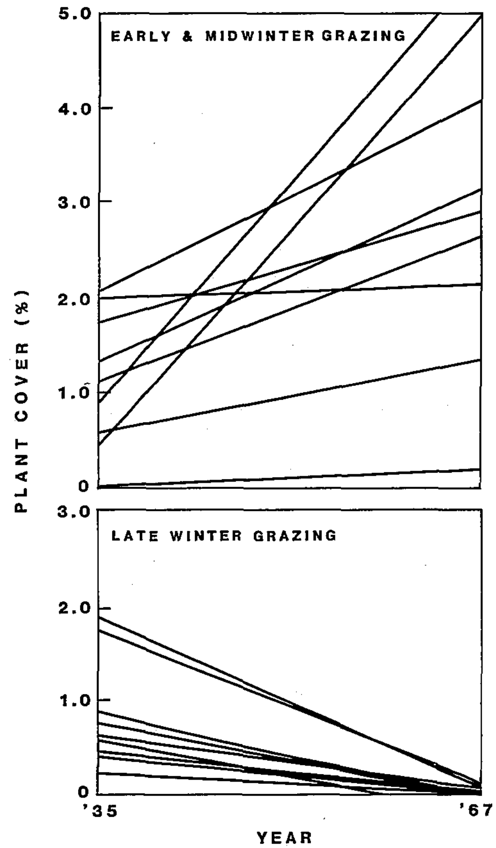


Figure 55.—Budsage on nine areas grazed in the cold part of the winter (top) maintained its original cover or increased, whereas it disappeared on nine areas grazed in late winter (bottom).

Plant response to season of grazing is related to stage of development. Two of three seasons, early winter and midwinter (late November to late February), are periods of plant dormancy, when the previous year's growth of grass is dead and shrub twigs are physiologically inactive. The third season, late winter (March into early April), is the time when growth of cool-season plants begins. Winterfat and especially budsage are vulnerable to grazing during that period. Budsage increased in cover in all nine areas grazed in early or midwinter, but decreased on areas grazed in late winter despite grazing intensity (fig. 55). Response of budsage is also related to palatability. It is grazed in midwinter is less than half the years. However, it is highly palatable to sheep every year in late winter, and it virtually disappeared in all pastures grazed during that season.

Clearly desirable species are damaged by late winter grazing, heavy use, or a combination of the two, as shown in the case of winterfat (fig. 56). However, such practices as periodic rest, rotation of use, or adjustments in rate of stocking have allowed range improvement. For example, one heavily stocked allotment was grazed only every other year. Black sagebrush was restricted to numerous small areas covering about 5 percent of the total. When the alternate-year grazing system was started, low rabbitbrush was the dominant species. Now black sagebrush has almost completely replaced rabbitbrush to form nearly pure stands. In this same allotment, the major plant community is winterfat-budsage. At the beginning of the study in 1933, it was composed almost entirely of winterfat and annual weeds.

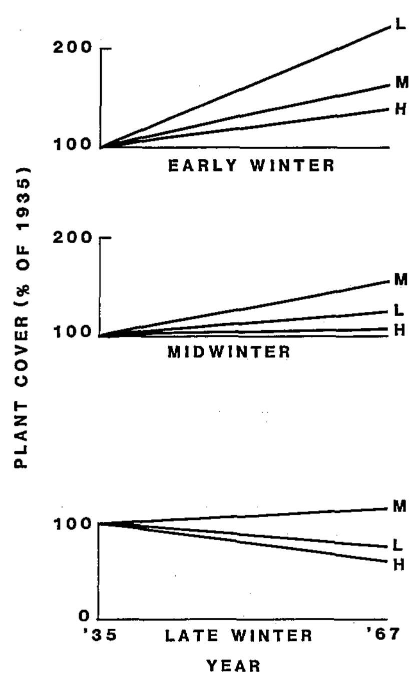


Figure 56.—Effect on yield of winterfat of season and intensity of grazing by sheep on the Desert Experimental Range.

In 1963, the percent composition of vegetation of this allotment was markedly different from an adjacent area grazed in winter or early spring every year:

Species	Rested every second year	Grazed every year
	Percent	*Percent*
Desirable		
Winterfat	47	64
Budsage	15	1
Black sagebrush	10	1
Indian ricegrass	10	8
Undesirable		
Low rabbitbrush	14	19
Others	4	7

Largely as a result of phenological differences, one palatable species may be more vulnerable than another during a particular season of use. A rather common example on ranges used only in the cold part of winter is the survival of forage grasses, while valuable shrubs are lost. At that time the aboveground parts of the grasses are dead, and harvesting takes away no food reserves needed for subsequent growth. With most forage shrubs, however, winter browsing removes living, although dormant, tissue. A number of shrub-grass ranges, whether used by cattle or sheep, have lost the valuable shrub component. Unless some other shrub of less value replaces the desirable shrubs, the aspect of such ranges becomes more grassy. This occurs more often on sheep range than on cattle range because fewer of the shrub species are used by cattle. However, if the dominant shrubs are winterfat or fourwing saltbush, this sort of change is the same under use by either kind of animal.

Hutchings (1966a) pointed out that studies at the DER clearly demonstrate two features of vegetation change:

1. Irrespective of grazing, herbage yields fluctuate widely from year to year, varying with amount of precipitation.

2. Irrespective of precipitation, the influence of grazing on vegetation is selective. Under poor management, desirable forage species are injured or destroyed and are replaced by undesirables. Good management usually reverses this process.

RECOMMENDED GRAZING MANAGEMENT

For about a century the salt-desert shrublands have been used primarily as livestock range. Because of natural aridity and lack of water for irrigation, they were unsuited for homesteading, so remained largely in public ownership. Until they were placed under the stewardship of public land management agencies, most parts of the desert had been misused for about a half century by livestock grazing. Stocking rates were too heavy, or the season of use, year after year, occurred during periods when the desirable forage species were most easily damaged.

Livestock use today is no longer unrestricted, and stocking is considerably lighter than it was before the establishment in 1934 of the Grazing Service (Bureau of Land Management since 1947). Herds now use assigned allotments at designated seasons. Traditionally, the use has been during winter and well into the spring, and for most areas that is still the case. On many ranges the spring season has been shortened by removing the animals at an earlier date than formerly, a practice that should benefit the forage species. On the other hand, as watering places for livestock have been developed, some desert ranges have been made usable for warm season grazing by cattle, the season when top removal is most damaging to plants (Cook 1971).

In the early decades of this century there were many more sheep than cattle on the desert, but since about 1930 sheep numbers have declined about 80 percent. Cattle have taken their place on many allotments. Most studies of grazing response of plants and animals have been concerned with sheep use (Hutchings and Stewart 1953; Cook and others 1953; Fisser 1966), and observations were made on a number of different plant communities. Regardless of what species were present, the palatable plants were damaged most by grazing, especially during the season of early and rapid growth. Response to cattle grazing was similar except that different species were impacted as a result of different dietary preferences.

The early devastation of much of the salt-desert as described by Wooton (1932), McArdle and others (1936), and Stewart and others (1940) appears now to have been checked; some areas have an obvious upward trend. True desertification was once described for areas that are now stable (fig. 57). The most severely depleted ranges are still in very poor condition, but others are grazed with fewer animals at seasons more compatible with plant survival, and range condition has improved.

Although vegetation may be only sparse stands of the least desirable perennial species or annuals, soil movement today is not as severe as 40 to 50 years ago. Most of the salt-desert shrub range has perennial cover, but much of it remains in poor condition because of the low percentage of desirable species.

Under good grazing management, it is possible for recovery to occur. Several examples of improved vegetal composition at and near the Desert Experimental Range have been described by Hutchings and Stewart (1953), Hutchings (1966b), and Holmgren and Hutchings (1972). Recovery has been most notable where depletion had been the least. The poorer the condition, the slower the recovery. As stated earlier, desirable plants are reestablished as the cover is opened by loss of the undesirable perennials.

Good range management in the salt-desert shrubland is optimum harvest of the forage resource by livestock. Good management strives for improvement in range condition, which includes a best combination of species for animal nutrition and stability of the site for continued production. It recognizes other values and uses of the land such as its potential as wildlife habitat or for recreational activities. Good management also brings greater returns to the livestock operator (Hutchings 1954) as range condition and productivity ultimately improve. Although recommended management is largely based on experience at the DER, the authors believe that the general principles developed there can be successfully extrapolated to other salt-desert shrub ranges.

Because these ranges ordinarily receive only light snowfall, produce unusually high quality winter forage, and are geographically close to the other ranges that can not be used in winter, their most valuable use is as winter range for livestock. Other reasons exist for recommending that the salt-desert be used only as winter or winter-early spring range. As has been noted, the growing season is the critical grazing period, perhaps more so in this arid ecosystem than elsewhere, because of the undependability of sufficient moisture for plant regrowth and recovery after grazing. Using the rate of runoff and sediment loss as indicators of soil stability, Lusby (1978 as cited by Bentley and others 1980) concluded that winter grazing is not detrimental, but grazing into the spring definitely is. Cook and Stoddart (1963) concluded that "desert ranges are best adapted to winter grazing and if used during this period would have about twice the grazing capacity as when grazed in the (late) spring."

Additonally, an algal crust protects the soil from blowing or washing away and covers the soil surface in the wide interspaces between the low plants. The crust seems better able to recover in the cool weather of early spring than later, after having been chopped and broken by hooves of grazing animals (Anderson and others 1982a; Anderson and others 1982b).

System

After 20 years of study, Hutchings (1954) recommended that winter-spring allotments be divided into smaller units, each to be grazed in succession, with an alternation or rotation of their period of use from year to year. Thus, the detrimental effects of late winter or early spring grazing would be lessened. He described the usual practice of allotments being grazed by sheep as one single large unit, saying that by such method "the entire range is 'topped' as soon as the sheep reach the winter range and then grazed repeatedly throughout the winter. By March the allotment has usually been grazed over several times and the sheep are dependent on short, poor-quality forage for the remaining part of the winter." Cook and Harris (1950) sampled a sheep allotment seemingly grazed in this manner for nutritive value of the forage as the winter progressed and found that quality did indeed become poorer.

Sheep that graze by the unit system appear to obtain adequate forage and graze contentedly, using all parts of the range uniformly. Hutchings (1954) reported that "they were not dependent on early spring growth during the late winter period or on short, poor-quality forage on previously grazed range." This is because they were moved regularly during the winter to fresh forage and held on a unit that provided an adequate diet. This method provided lower quality forage throughout the winter than what the animals would have had in the first time or two over the allotment by the usual practice, but better than what would have been available for late winter on ranges that were already topped and retopped.

The unit system should be followed for both cattle and sheep. Hutchings (1954) recommended three or four units. It seems desirable that there be more than that on an allotment that is to be grazed for as long as 5 months. Certainly this would be easy to accomplish with sheep. For cattle, a cost factor for fences must be considered. With more and smaller units and hence a shorter stay on each one, it is easier to estimate how much of the area can be used each day. If the estimate is too low, the animals will spend only a few days on range already grazed before going onto the fresh forage of the next unit. On larger (and fewer) units such times of low-quality forage are likely to be several days or weeks.

To benefit the palatable shrubs, frequent periods of rest should be part of the program, providing some years with no grazing at all for about a third of the total allotment area. Grasses are little affected by use in the dormant period (Hutchings and Stewart 1953; Cook 1971) because at this time their tops are cured and not important locations for stored food reserves. However, twigs of shrubs, and leaves of those that are evergreen, are living tissue. Shrubs are less damaged by grazing during the cold weather period of dormancy than during spring growth, but they are at a disadvantage compared to grasses. Additionally, the shrub habit of growth is one of gaining annual increments of stature—each plant becomes larger year by year and thereby individually more productive. With a year of no grazing, there will be 2 years of plant growth when the animals return the following winter. And after they have been harvested, the plants will be larger than they would without rest. Vigor and seed production will be greater. At the DER, one rather heavily stocked area used only in alternate years contains two desirable shrubs (budsage and black sagebrush) that were not thought important because they were so rare. Now, however, they are abundant components of a useful mixture of forage species. On other areas where there was no rest, the palatable shrubs present in minor amounts have not been able to make such dramatic gains, and in many places have actually declined further.

Various grazing regimens under the unit system have not been adequately compared, but several combinations of rotation, deferment, and rest all seem to be beneficial, provided they allow periodic protection from grazing during critical period of spring plant growth.

The unit system benefits wildlife as well as vegetation and livestock. Clary and Holmgren (1981) reported that pronghorn tended to occupy range areas not grazed by sheep. The pronghorn diet, primarily browse in winter (Beale and Smith 1970; Smith and Beale 1980), consists of fewer species than taken by sheep and is comprised of those most highly preferred by the sheep. On much of the desert, these are often the species of least abundance, and the ones most heavily grazed.

When the whole allotment is grazed over by sheep early in the winter, the pronghorn forage is essentially gone. Replenishment by new growth is still months away. Under the unit system, some areas remain ungrazed by sheep until spring plant growth. Pronghorn use these areas, returning in late winter or early spring to units that were grazed by sheep when the plants were dormant. The delay or deferment of entry of sheep into some of the units makes the mutual use of the winter allotment by these two animals more compatible, allowing for higher productivity of the wildlife.

Stocking Rate

Amount of herbage that can be removed without serious damage varies with species and with season of use. Because palatability, and hence degree of use of a particular species, is related to inherent characteristics, abundance, site, and season, it is readily apparent that estimation of range grazing capacity can be extremely difficult. Likewise, the "key species" concept is difficult to apply where composition of the vegetation has been so thoroughly changed by decades of unmanaged livestock use that some of the most desirable forage species have been lost. However, as noted earlier, with proper management minor species can regain their former position and ultimately improve the variety and quality of winter forage.

Stocking, therefore, must be based on the present species and their allowable use. Hutchings (1954) recommended 40 to 80 percent use of the annual growth for the most desirable (good) species, 20 to 40 percent for the moderately desirable (fair) species, and less than 20 percent for the least desirable (poor) species (table 2). He further stated that "periodic checks on the utilization of forage plants are essential in determining whether the range is properly grazed. Average utilization ratings, such as shown in table 2, established on properly grazed ranges and often referred to as proper use factors, serve as guides for proper grazing. These recommended ratings represent the average maximum allowable use of the desirable species and the use that less desirable species ordinarily receive when the desirable species are properly grazed." However, the clipping studies of Cook and his associates (Cook 1971; Cook and Stoddart 1963; Cook and Child 1971) suggest that the intensity of use recommended by Hutchings for some of the shrubs may be too high.

Hutchings (1954) covered several considerations in determining stocking rates. With minor modifications, his material is directly quoted to the end of this section:

Determine proper number of animals to be grazed.—The proper number of animals to be grazed on a range during the winter grazing period (grazing capacity) is determined primarily by the kind and amount of herbage produced and range condition. The range should be stocked according to the best estimates of grazing capacity that can be obtained. These should be modified or adjusted later by careful and frequent checks on forage utilization and trend in range condition. Preliminary estimates of grazing capacity can be made by several methods.

Stocking rates based on past records of use can serve as an index to grazing capacity. If the range has shown no improvement or if the desirable forage species are being injured or destroyed, fewer animals should be grazed or the grazing season shortened. If the range is in good condition and more herbage is left ungrazed than is needed to keep the desirable forage species thrifty and productive, more livestock can be grazed.

Stocking rates on similar nearby ranges that are properly grazed can also be used to make preliminary estimates of grazing capacity. In applying this information, it is necessary to allow for differences in herbage production and condition of the two areas.

Table 2.—Recommended winter use of desert range forage species (adapted from Hutchings 1954)

Forage species	Recommended use of annual growth (percent)
GOOD	
Shrubs:	
Spiny hopsage	80
Black sagebrush	70
Winterfat	60
Budsage	50
Fourwing saltbush	50
Gardner saltbush	40
Grasses:	
Indian ricegrass	75
Alkali sacaton	75
Squirreltail	75
Needle-and-thread	50
Galleta	45
Forbs:	
Globemallow	80
FAIR	
Shrubs:	
Fringed sagebrush (*Artemisia frigida*)	40
Gray molly	35
Shadscale	25
Big sagebrush	20
Grasses:	
Sand dropseed	25
Saltgrass	25
Blue grama	20
POOR	
Shrubs:	
Snakeweed (*Gutierrezia sarothrae*)	15
Low rabbitbrush	10
Rubber rabbitbrush (*Chrysothamnus nauseosus*)	10
Black greasewood	5
Grasses:	
Cheatgrass brome	10
Forbs:	
Russian thistle	10
Halogeton	0

Allow for range condition.—Ranges in good condition have considerably greater grazing capacity than those in poor condition because they produce more total herbage and a greater proportion of desirable forage species.

To encourage rehabilitation of ranges in poor condition, the better forage plants should be grazed less than is recommended for ranges in good condition. The desirable plants in weakened condition require greater protection and food reserves to restore them to thrifty, vigorous production, so they can compete successfully with the less desirable plants.

Allow for variation in forage yield.—Forage yields on winter ranges vary widely from year to year. For example, at the Desert Experimental Range, forage production (during 18 years from 1935 to 1974) on shadscale-winterfat range in fair to good condition varied from a minimum of 30 lb per acre (34 kg/ha) in 1943 to a maximum of 169 lb per acre (190 kg/ha) in 1947. The average was 81 lb per acre (91 kg/ha) (fig. 58).

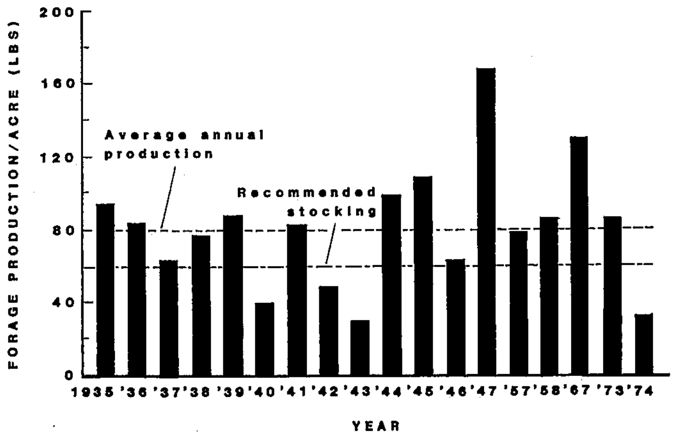


Figure 58.—Forage production on moderately grazed range areas at the Desert Experimental Range, 1935 to 1974. Recommended stocking is based on 75 percent of average forage production, which provides adequate forage except in years when production is extremely low (adapted from Hutchings 1954).

Because of the normal inability to adjust animal numbers to the wide variations in forage yield, basic stocking is recommended at 75 percent of average forage production. On this basis enough forage was available in the years shown and no adjustments in stocking would have been necessary except in the drought years of 1940, 1942, 1943, and 1974. Judging from available records, supplemental feed or some adjustments in stocking on winter ranges will be required in 2 or 3 years out of every 10.

In years when forage production is good, utilization of the desirable forage species will be somewhat less than the percentage listed in table 2, if the ranges are stocked at 75 percent of average production. The extra herbage left will help the plants recover from drought years and also help to build extra food reserves.

Severe droughts markedly lower the grazing capacity of winter ranges. During such periods total herbage production is often only a third of average. Effects of drought are often apparent on the range for 2 or 3 years. Light stocking may, therefore, be needed following severe drought. This is especially true on ranges where many of the desirable species are killed or injured by the combined effects of overgrazing and drought.

Fortunately most of the forage on winter ranges is produced before the winter grazing season begins. About 60 percent of the growth is made by the end of July and completed by September, almost a month before grazing starts. This gives stockowners an opportunity to examine the range, estimate forage available for winter, and make necessary arrangement to care for their animals during winters when forage is short.

In general, amount of precipitation and total herbage production are closely associated. In years when precipitation is high, herbage production is high; when precipitation is low, herbage production is likewise low. Yields in years of high rainfall have been as much as six times as great as yields in drought years.

At the Desert Experimental Range, herbage production as measured in October was found to be closely related to the precipitation that was received during the preceding 12 months (October to September). Because of this close relationship, the size of the forage crop that is available for winter grazing can be estimated rather accurately from rainfall by using figure 59. For example, if the precipitation for October to September is 7 inches (17 cm), the approximate herbage production on the range in October would be 230 lb per acre (259 kg/ha). This can be read from figure 59 by the dotted arrows on the chart.

From such an estimate of herbage production the stockowners can determine the available forage crop a month or two ahead of the grazing season. They then have ample time to make adjustments in stocking or to provide supplemental feed for anticipated short forage crops during emergency drought periods.

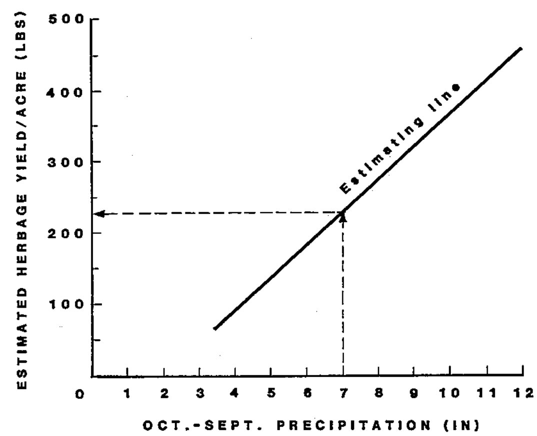


Figure 59.—Chart for estimating herbage yields in October, based on relation of October herbage yields to precipitation received during the preceding 12 months at the Desert Experimental Range (from Hutchings 1954).

Animal Distribution

In addition to a "unit" grazing system that allows rotation of use, periodic rest, and proper stocking rate, an effort must be made to obtain even distribution of livestock over the entire allotment. Topography, kinds and patterns of vegetation, location of watering places, and size and shape of individual units all influence livestock distribution.

With sheep, type of herding can be especially important. Hutchings (1954) has provided some useful suggestions on this practice:

> Good herding and careful management of the flock are essential to proper grazing. Herding is a full-time job, and a good herder spends most

of his time with the flock, directing the course of grazing and allowing the sheep to graze quietly throughout the day without excessive trailing. For good management the following herding practices are recommended: (1) plan the routes of grazing to provide a variety of forage with some fresh ungrazed country every day; never, except in emergencies, round up the herd and trail to new areas; (2) allow the sheep to spread out and graze quietly, but do not allow them to trail back and forth across the range; and (3) bed the flock in a new location each night wherever nightfall overtakes them.

With cattle in large fenced units, use is heavier near water than in areas miles away. The disadvantages, both to the animals and to the range, of insufficient watering locations have been stated by Stoddart and Smith (1955). When there is snow on the ground, both cattle and sheep range farther from water than when there is no snow. Cattle come in to water less frequently then, and sheep do not drink at all. Hutchings (1958) strongly recommends hauling water to sheep for better distribution and to allow improvement of range condition in the neighborhood of such permanent waters as wells, ponds, and developed seeps. He shows that watering on the range where the sheep are grazing each day benefits both sheep and range. Costello and Driscoll (1957) recommend hauling water to cattle. By moving portable troughs from place to place on large cattle grazing units, the animals will be enticed to areas they may otherwise not use.

ANIMAL NUTRITION

Because salt-desert ranges ordinarily receive only light snowfall, produce high-quality winter forage, and are in juxtaposition with other ranges unsuited for winter grazing, their most valuable use is winter range for livestock (Holmgren and Hutchings 1972). Such use is not incompatible with present and potential value for wildlife habitat and recreational activities. This so-called winter range is actually a winter-spring range. Most bands of sheep use the salt-desert shrub range from November through April. Cattle graze these ranges during the same period, usually on separate units, and also during other seasons.

The shrubby species of the salt-desert shrub ranges grow in association with various grasses. The shrubs are higher in protein, phosphorus, and carotene (vitamin A) than grasses, whereas grasses are superior only in energy-yielding qualities (Cook and others 1954). If animals are expected to subsist during the winter on range forage alone, a mixture of shrubs and grasses will undoubtedly come closer to meeting the requirements of a balanced ration than either alone.

Range forage, unlike most cultivated crops, is selected in an assortment determined by preferences of the grazing animal. Kind and amount of forage taken is influenced not only by kind of animal, but also by intensity of grazing, species mixtures present, stage of growth, abundance of forage, and weather conditions (Cook and others 1954). Consequently, it is difficult to evaluate the nutritive content of the diet. Value of range forage is further complicated by factors that affect chemical composition of the forage plants such as type of soil, site, stage of growth, and degree of weathering.

During winter when livestock are in gestation, nutrient requirements are only slightly higher than for maintenance. If the animals are in good condition at the beginning of winter, they can lose some weight and still remain healthy. According to Cook and Harris (1968), feeding supplements may increase production but not always enough to offset additional costs. These authors also conclude that it is unwise to supplement with energy when another nutrient such as phosphorus, protein, or vitamin A is limiting production. However, one of the first requirements range animals must meet is energy, because they frequently travel long distances to acquire forage and water. In addition, they must maintain body temperature during the winter without the aid of shelter. When energy-supplying carbohydrates and fats are inadequate, the animal will use protein for energy and further aggravate any protein deficiency already present in the diet.

Contrary to their earlier conclusion, Cook and Harris (1968) suggested that protein supplements such as cottonseed or soybean meal are perhaps better supplements on winter ranges than energy feeds such as corn and barley, even when energy is substantially low in the animal's diet. Such supplements as corn and barley have a tendency to reduce the digestibility of cellulose and other carbohydrates of range forage and, therefore, do not substantially increase the total energy intake. The protein supplements actually increase the digestibility of most nutritional constituents in range forage and thereby enhance its nutritive value. Feeding supplements on salt-desert shrub ranges may decrease the quantity of range forage consumed.

The nutrient content of an animal diet on good and poor condition winter range depends upon the vegetal composition and the degree of use (Cook and Harris 1968). Daily intake is usually less on poor than on good condition ranges. This may result from more time spent in searching for forage and being forced to consume less palatable plants. However, light use of the unpalatable species may be associated with extremely heavy use of the more palatable ones.

Harris and others (1956) conducted a study of effect on sheep of providing supplemental energy, protein, and phosphorus, separately and in combination, during the time the animals were on the winter range. They found all three to improve animal performance (animal weight, wool production, and lamb crop) over that of unsupplemented animals. Weights dropped off after late December under all treatments, but at significantly greater rates for sheep not receiving supplements than for those that did. The report does not describe how the range was grazed or the condition and quality of the native forage. However, in animal performance the results are similar to what Hutchings and Stewart (1953) found in comparing grazing by the unit system that had good animal distribution, with grazing by going over the allotment several times during winter. In that study, animal weights, wool production, and lamb crops were better among ewes in the unit system where they were frequently placed on fresh forage than on the range where forage quality was declining steadily because of the grazing method. Merits of supplemental feeding and proper grazing method may still be debated, but Harris and others (1956) state that "supplementary feeding should never be a substitute for good range management." We feel that supplements should be provided only at times of extreme emergency, as when snow is so deep that forage is inaccessible and the animals cannot be moved. Of course, feeding at such times would be more than supplemental to the range forage. It could necessarily constitute most or all of the diet.

RANGE PESTS

As do other western rangelands, salt-desert shrub communities include some species of animals and plants that sometimes create management problems. Insects, rodents, rabbits, and annual weeds can all have serious impacts. Unfortunately, many of them are not well understood.

Insects

Among the few studies of insects in salt-desert shrub ecosystems is Fautin's (1946) identification of some 65 species in shadscale and more than 100 species in greasewood communities of western Utah. A wide variety of insects inhabit salt-desert shrub communities, but only a few cause significant damage to the vegetation. Most of the insects are native species that usually occur in insufficient numbers to cause obvious damage. Nevertheless, they may affect vigor of individual plants, their ability to compete with others, and lifespan. For example, in a life history study of budsage, Wood (1966) noted that accurate ring counts were difficult to obtain because the centers of stems and roots were often eaten by boring insects. West (1982) suggested possible damage to shrubs by cutworms (larvae Noctuidae). Indian ricegrass was totally eliminated from large areas at the DER by a combination of insect larvae and drought (Guerra 1973).

Because they are apparently responsible for vast areas of partially denuded range, harvester ants (*Pogonomyrmex occidentalis*) have created serious concern among ranchers and professional range managers. In Gardner saltbush and shadscale communities in southern Idaho, Sharp and Barr (1960) assumed that ant activity caused a reduction in livestock grazing capacity, an increased potential for soil erosion, and destruction of a large amount of seed, especially that of the grasses. Because areas in poor condition and infested with halogeton and other annuals had a preponderance of ant clearings, they concluded that maintenance of good condition ranges was important in keeping ant populations at reasonable levels. In similar studies on Gardner saltbush range in Wyoming, Wight and Nichols (1966) concluded that loss of forage was not significant because increased moisture created a border effect that largely compensated for loss of vegetation within the clearing. However, possible changes in vegetation composition and esthetics should make it desirable to continue the search for effective and economical methods for harvester ant control.

Severe damage to shadscale in southern Idaho by a snout moth of the family Pyralidae was reported some 30 years ago (Hutchings 1952). Defoliation by the larvae had apparently killed most of the shadscale on more than 20,000 acres (8 000 ha) allowing the invasion of undesirable annuals, especially halogeton. Fortunately, this was an isolated case. Apparently the usual situation is an ecological balance between the insects and vegetation with minimal damage to the latter. However, when insect populations are triggered by favorable environmental factors, some of the shrubs can be severely damaged.

Rodents and Rabbits

Rodents and rabbits are singled out as pests, perhaps unfairly in some cases, because of their obvious consumption of or damage to vegetation of salt-desert shrub communities. However, they undoubtedly serve several useful purposes such as food for predators and consequent lessening of impacts on game animals and livestock, use of their dens for shelter by other animals and birds, soil building activities related to burrowing and excreta, accumulation of plant seed caches that subsequently sprout, and use as game by hunters or objects of interest by recreationists.

Some common species of rodents and rabbits in salt-desert shrub communities of western Utah were listed by Fautin (1946) and Vest (1962). These include the chisel-toothed kangaroo rat (*Dipodomys microps*), Ord kangaroo rat (*Dipodomys ordii*), least chipmunk (*Eutamias minimus*), deer mouse (*Peromyscus maniculatus*), harvest mouse (*Reithrodontomys megalotis*), little pocket mouse (*Perognathus longimembris*), kangaroo mouse (*Microdipodops megacephalus*), antelope ground squirrel (*Ammospermophilus leucurus*), Townsend ground squirrel (*Citellus townsendi*), pocket gopher (*Thomomys bottae*), cottontail rabbit (*Sylvilagus nuttallii*), and black-tailed desert jackrabbit (*Lepus californicus*).

Many rodents and rabbits have distinct food preferences that, in combination with type of cover, strongly influence their preferred habitats. According to Vest (1962), the chisel-toothed kangaroo rat prefers shadscale, but also eats considerable fourwing saltbush and greasewood, whereas the Ord kangaroo rat prefers fourwing saltbush, but also feeds on greasewood, Russian thistle, and grass. Little pocket mice seem to prefer seeds of ricegrass, alkali sacaton, and annual forbs. Deer mice feed on and store leaves and seeds of shadscale. A food cache of a deer mouse consisted almost entirely of shadscale leaves and seeds. Antelope ground squirrels store shoots and seeds of grasses, and the seed caches frequently germinate the following spring. Both antelope and Townsend ground squirrels also feed on a variety of shrubs. Although gopher populations are generally low in salt-desert shrub communities, they may eat considerable quantities of grass and forb herbage and also kill plants by feeding on their roots. Furthermore, gopher populations are cyclic and during times of high density can be destructive. Cottontail rabbits are not abundant in salt-desert shrub communities, so their impacts on vegetation are light. Because of their size, jackrabbits can consume considerable quantities of forage even when populations are low. Although grasses are highly preferred, various shrubs and forbs may also be heavily used. As with most of the rodents, jackrabbits often cut much more forage than they consume, leaving considerable waste on the ground.

West (1982) described the black-tailed desert jackrabbit as the major vertebrate consumer in the salt-desert shrub ecosystem, but this may be true only in certain situations. Numerous observers report that jackrabbits prefer the cover of large shrubs such as greasewood and big sagebrush, and that their populations are generally low in shadscale, winterfat, black sagebrush, and other small shrub communities unless they are adjacent to areas occupied by the larger shrubs. An extensive survey in Nevada and adjacent States during summer 1957 showed a strong relation between distribution of sagebrush and high jackrabbit populations (Adams and Adams 1959). However, Currie and Goodwin (1966) demonstrated possible impacts of jackrabbits on salt-desert shrub ranges in northwestern Utah. They concluded that during a given period 5.8 rabbits consumed or wasted the amount of forage equaling the food requirement of one sheep. In addition to preferred grasses and forbs, principal shrub species used were winterfat, shadscale, Gardner saltbush, and big sagebrush. Because rabbit and sheep preferences are notably similar, impacts on sheep ranges could be especially high.

In an unpublished study at the Desert Experimental Range in southwestern Utah, Holmgren concluded that the salt-desert shrub vegetation supported a population of rodents weighing about 1 lb per acre (1.12 kg/ha). When the high energy requirement of the small rodents is considered, use of vegetation by these animals is an important factor.

Annual Weeds

For the most part, native annuals are relatively unimportant components of salt-desert shrub ranges in good condition, where perennial species offer severe competition for limited moisture. In these situations, production of annuals is low except in unusual years when they are able to thrive on above-normal precipitation. Likewise, they are sometimes able to take advantage of improved moisture conditions when the perennial stand has been weakened or destroyed by overgrazing or other disturbances. However, the principal impact of annuals is from three Old World species—cheatgrass, Russian thistle, and halogeton. These aggressive weeds, especially the latter two, can readily invade and dominate depleted salt-desert shrub communities, but they have little success in competing with vigorous stands of native perennials on good condition ranges.

Cheatgrass and Russian Thistle are Jekyll-and-Hyde species. They fill the void when desirable perennials are destroyed, and provide soil protection and considerable livestock forage. On the other hand, their production fluctuates greatly, and they are not dependable for either soil protection or forage. Halogeton has many of the characteristics of Russian thistle, but is also poisonous to livestock, especially sheep, and has been responsible for large losses on ranges of Utah, Idaho, and Nevada.

The obvious solution to annual weed problems on salt-desert shrub ranges is to maintain or create a closed stand of desirable perennials that will limit invasion and growth of weedy species. Need for control of rodents and rabbits, especially the latter, should not be overlooked, as their impacts can be severe (Eckert 1954; Frischknecht 1968). Also, care should be taken to prevent undue vegetation destruction by road construction, surface mining, or use of off-road vehicles. Where depletion of native vegetation has been severe, complete protection for many years or revegetation may be necessary. The latter can be difficult.

Although herbicides such as 2,4-D are effective in killing halogeton plants (Cronin and Williams 1966; James and Cronin 1974; Miller 1956), destruction of an entire stand is virtually impossible (Tisdale and Zappettini 1953). Furthermore, black seeds that can germinate immediately and brown seeds that may persist in the soil for at least 10 years provide a reliable means of reinvasion. However, the main deterrent in use of 2,4-D is that it also kills desirable native forage species. For example, Cook and Stoddart (1953) reported that 2 lb per acre (2.25 kg/ha) of 2,4-D was required to effectively control halogeton, whereas 1.5 lb per acre (2 kg/ha) killed winterfat, gray molly, and shadscale but only the tops of associated halogeton.

Because elimination of halogeton from salt-desert shrub ranges of the Great Basin by present methods is not economically or ecologically sound, range use is dependent upon learning how to graze infested areas with least damage to native perennial vegetetation and minimum livestock losses (Cook and others 1952). Halogeton poisoning usually occurs when hungry animals are being trailed through heavy infestation or when shipped in and unloaded into dense stands of the weed. At one time it was popular to use calcium supplements to alleviate halogeton poisoning (Cook and Stoddart 1953). However, this practice proved unsatisfactory and is no longer recommended. James and Cronin (1974) have several recommendations for preventing losses:

1. Allow sheep time to adapt to the oxalate responsible for poisoning by grazing plants such as shadscale, Russian thistle, and Gardner saltbush that contain only small amounts of the oxalate. Then, introduce animals to halogeton-infested areas gradually.

2. Never allow hungry animals to graze in large, dense patches of halogeton as found on trails, old bedgrounds, or around watering places.

3. Watch the livestock and know what vegetation is available and what plants are being grazed. Provide supplemental feed and water before moving into potentially hazardous situations.

REVEGETATION

Original vegetation on many parts of the salt-desert shrub range has been severely damaged, destroyed, or replaced by less desirable species. Soil has also been lost through wind and water erosion, and environmental amenities have been altered. Although restoration of an adequate cover of desirable vegetation is needed, depleted salt-desert shrub ranges are slow to improve under either good management or complete protection. Therefore, direct revegetation may be the only satisfactory solution. Unfortunately, the different and harsh environment of salt-desert shrub ranges prevents the use of species and methods that have been successful in direct seeding of other western ranges.

Problems encountered in revegetation of salt-desert shrub rangelands were reviewed by Bleak and others (1965), who examined more than 100 seedings of grasses and shrubs in Utah and Nevada, some as old as 25 years. Their conclusions are summarized in the following paragraphs:

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 (8 to 20 cm). 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. However, a few plantings of the introduced crested wheatgrass (*Agropyron desertorum*), fairway wheatgrass (*Agropyron cristatum*), Siberian wheatgrass (*Agropyron sibiricum*), and Russian wildrye (*Elymus junceus*) maintained stands for 10 or more years.

Although resident shrubs and grasses dominated the various communities within the zone, good stands of these natives were difficult to obtain by artificial seeding. Low seed viability and seed dormancy were problems. Because 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 died 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 caused much damage 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 and grasses that dominate the natural communities within this zone.

Hull (1963) made experimental seedings with 14 species of grass on 18 salt-desert shrub areas in Wyoming from 1948 to 1950. Although initial stands were encouraging and many persisted for several years, scarcely any of them could be considered successful after 12 years. Russian wildrye was the most successful species used, followed closely by crested wheatgrass. Many reasons have been suggested for rehabilitation failures from direct seeding in the salt-desert shrublands (Van Epps and McKell 1980), including low seed germination, unadapted species or ecotypes, frost or winter kill of emerged seedlings, improper depth or season of planting, inadequate seedbed preparation, seed removal by animals, grazing damage, excessive competition from other plants, lack of soil moisture, low precipitation and hot winds during critical growth periods, soil compaction, diseases, and perhaps the absence of beneficial mycorrhiza.

Because even the best-adapted of the introduced grasses seldom last longer than 10 to 12 years in salt-desert shrub areas (Plummer 1966), rehabilitation practices should minimize damage to native vegetation so that it can increase as the introduced species disappear. Grasses, forbs, and shrubs have been seeded into partial stands of native shrubs, especially shadscale and winterfat, but usually with marginal results. Because of the inherent harshness of salt-desert shrub sites, revegetation projects should be approached with caution.

Although the list is much shorter than for other western ranges, a number of species have been recommended for revegetating salt-desert shrublands (Plummer 1966; Plummer and others 1968; McArthur and others 1978). In addition to such exotics as Russian wildrye, crested wheatgrass, and tall wheatgrass (*Agropyron elongatum*), several native grasses including Indian ricegrass, sand dropseed, alkali sacaton, basin wildrye (*Elymus cinereus*), blue grama, needle-and-thread (*Stipa comata*), Salina wildrye (*Elymus salinus*), and bottlebrush squirreltail have been used with some success. Only a few forbs appear adapted for seeding salt-desert shrub areas: gooseberryleaf globemallow, American licorice (*Glycyrrhiza lepidota*), Lewis flax (*Linum lewisii*), and small burnet (*Sanguisorba minor*). Shrubby chenopods that have shown promise in trial plots for seeding salt-desert ranges include fourwing saltbush, winterfat, shadscale, Gardner saltbush, Castle Valley clover, mat saltbush, and spiny hopsage. In addition to these native species, prostrate kochia (*Kochia prostrata*), an introduction from Eurasia, has shown potential usefulness in a number of situations. Several shrubby composites are also recommended, especially in soils with the lower concentrations of salt and alkali. These include big sagebrush, black sagebrush, budsage, rubber rabbitbrush (*Chrysothamnus nauseosus*), and low rabbitbrush.

For the most part, mixtures of grasses, forbs, and shrubs are preferable to single species (Plummer and others 1968; McArthur and others 1978) because (1) many seedings are on terrain that includes diverse microhabitats, (2) some plants benefit others by providing habitat and nutrients, (3) diseases and insects do not attack all species equally, (4) a mixed diet is usually more palatable and nutritious for herbivores, (5) variation in time of growth extends the period of succulent forage, and (6) mixed vegetation provides habitat for a great variety of wildlife.

Seed should be planted in late fall or early winter. This will avoid precocious fall germination, overcome seed dormancy, take advantage of moisture from spring snowmelt, and minimize destruction of seed by animals that would then be in hibernation. Suitable mixtures might be composed of equal parts of 8 to 10 species and seeded at the rate of 10 to 12 lb per acre (11 to 13.5 kg/ha).

Seeding in salt-desert shrub communities, especially those dominated by shadscale, can be accomplished without major reduction of existing shrubs. The rangeland drill can be used to good advantage, especially when it is adjusted to make furrows of maximum width, or a browse seeder equipped with narrow scalpers will be satisfactory in many situations. Anchor chains, pipe harrows, and disks will destroy too much of the native vegetation and generally should not be used.

Despite the somewhat optimistic tone of the above discussion and recommendations, "successful procedures and species for seeding in drier areas have not been developed well enough for us to recommend large-scale seedings" (Plummer and others 1968).

Where depletion of salt-desert shrub vegetation has been especially severe, say from mining or road construction, or where fairly rapid revegetation is important, special measures may be justified to assure success. These areas are relatively small compared to the broad expanses of rangeland where livestock grazing has been the major disturbance. On areas where success is mandatory and cost is of secondary importance, such normally prohibitive measures as intensive soil preparation, use of soil amendments, improved moisture condition through mulches or drip irrigation, and use of transplants rather than seed may all be employed to insure successful revegetation (McArthur and others 1978; Frischknecht and Ferguson 1979; Van Epps and McKell 1980).

Transplanting requires a choice between bare-root and container-growth stock. Although survival of the latter is generally higher (Van Epps and McKell 1980), the economy of growing and ease of handling make a good case for bare-root stock, especially when conditions are favorable. Water conservation through mulching or use of pits and furrows usually improves plant establishment, as does supplying additional water through drip-irrigation or other means.

INTEGRATION OF MULTIPLE USES AND VALUES

Although the primary use of salt-desert shrub range has been grazing by domestic livestock, increasing recognition has been given to its use as wildlife habitat, as wildland with many recreation opportunities, as a source of important minerals, and as a resource reserve available for supplying presently unforeseeable needs. Consequently, maximum livestock production is a reasonable goal only when it does not conflict with other resource uses and values. Despite the apparently simple composition of salt-desert biotic communities, interrelations of the various ecosystem components can be complex, and manipulations through management can have serious consequences. Livestock grazing, selective plant control, and introduction of new species through seeding and planting can greatly influence habitat quality and wildlife populations. Likewise, hunting or other control measures can upset balances among animal populations. For example, the relative abundance of rabbits and rodents appears to be an important factor in amount of predation on pronghorn antelope by coyotes, bobcats, and golden eagles (Beale and Holmgren 1979).

Associated plant communities such as sagebrush-grass and pinyon-juniper, and inclusions of aquatic and riparian vegetation, are important as wildlife habitat and for their recreational values—often far out of proportion to the area they occupy. Because all these are normal components of most salt-desert shrub ranges, they must be given special consideration in the development of management prescriptions.

Wildlife

Although animal populations of salt-desert shrub ranges are seemingly sparse and simple, a considerable number of species varying in size from insects to large ungulates are normal inhabitants. A tendency exists to categorize them as desirable or undesirable depending on personal taste and whether their activities and effects on the ecosystem are perceived as good or bad. Insects, rodents and rabbits, and lizards and snakes are commonly considered undesirable, whereas songbirds and such game species as mourning doves and antelope are usually considered desirable. In between are the predators—hawks, eagles, kit foxes, bobcats, and coyotes—which may be hated, loved, or merely tolerated. However, until more is known about impacts or values of the various species, it seems prudent for the manager to maintain an open mind.

A number of factors influence faunal composition including kind of salt-desert communities and their condition, other associated plant communities, available water, topography, soil, weather, livestock grazing, and interrelations of the various animal species. Because some of these factors can be manipulated to improve habitat for particular species, opportunities exist for favoring populations of at least a few of them. At a minimum, livestock grazing and range improvement practices should be compatible with good habitat for game species such as antelope and doves or rare species such as the bald and golden eagles.

Antelope.—Pronghorn antelope is the most important game animal on most salt-desert shrub ranges, but numbers are often sparse. For example, in western Utah there is only about one animal per 5 square miles (13 km^2) of potentially usable range, whereas pronghorn food requirements and composition of the vegetation indicate that such range should be able to support 5 animals per square mile (2.6 km^2)—a 25-fold increase (Beale and Holmgren 1979).

This low antelope production has been a perplexing problem in Utah for many years. However, studies by Beale and Smith (1970), Beale and Holmgren (1974), Smith and Beale (1980), and Clary and Holmgren (1981) show the importance of adequate water during the summer, fawn losses due to predation, and competition with domestic livestock for preferred winter forage species.

Although many factors affect the amount of water necessary to maintain healthy and productive antelope herds, they cannot live without drinking water for extended periods during the summer on most salt-desert shrub ranges, even when forage is above average in succulence. Because free water is usually in short supply, providing drinking water through spring development, construction of guzzlers (fig. 60), hauling, or other means will expand the area of usable range and increase the density of antelope. Water developments for livestock will undoubtedly be used by antelope and other wildlife, especially if they are designed and managed to fit wildlife needs.

Because birth rates are generally high, fawn mortality must be responsible for low herd productivity. Although forage conditions may affect fawn survival, especially the abundance of succulent forbs during the summer months, predation appears to be the most important factor. For example, on a captive antelope herd at the DER during the 4 years 1975 to 1978, observations showed that coyotes, golden eagles, and bobcats killed about 60 percent of the fawns (Beale and Holmgren 1979). Jackrabbits supply a major part of the diet for coyotes, so Beale and Holmgren (1979) speculated that the relative abundance of other prey species, such as rabbits and rodents, may significantly affect predation on antelope fawns.

Although competition between domestic livestock and antelope has been regarded as a cause of low antelope productivity, Smith and Beale (1980) concluded that this was not serious on the deserts of western Utah because many plants grazed by antelope provide little or no forage for livestock. Forbs used by antelope in summer are ephemeral and therefore not present in winter when livestock are on the range. Species such as snakeweed and desert almond, both of value to antelope, are of minor importance to livestock, whereas winterfat and shadscale, both used by livestock, are largely ignored by antelope. However, winter diets of antelope and sheep do overlap in the case of black sagebrush, and competition can be severe when it is in short supply. For this reason, a grazing system is desirable that leaves a portion of the allotment ungrazed by sheep each year. Alternation of use by sheep and cattle could also give relief to the black sagebrush, enabling it to regain vigor without having to forego use of the range.

Systematic observations (Clary and Holmgren 1981) on the DER during winter show a pattern of antelope leaving units that were grazed by sheep and not returning until plant growth has begun in the spring. The researchers concluded that even moderate use by sheep during the dormant period is unfavorable to antelope until regrowth has occurred. However, the expanding population of antelope on the DER suggests that a rotation-deferred grazing system that provides some range ungrazed by sheep at all times has resulted in a satisfactory situation for the pronghorn.

Upland game birds.—Salt-desert shrub ranges provide especially good habitat for mourning doves, which are widely distributed wherever free water is available (Hancock 1966). Although doves nest at a considerable distance from water, it is vital to their survival and welfare in this desert habitat. Dove hunting is a fairly popular sport. Birds will accommodate more hunters than will larger game.

Chukars and sage grouse may also occupy salt-desert shrub ranges, especially peripheral areas where preferred habitat is available. Chukars are found near rocky escape cover and areas dominated by winter annuals, whereas sagebrush communities must be present to attract sage grouse.

Water is needed for all of these birds, and habitat improvement is often restricted to water development. Installations are commonly of the "guzzler" type (fig. 60) with a collecting apron, storage tank, and a small drinking fountain with a float valve for minimal waste and evaporation.

Other wildlife.—Other species of some prominence in the salt-desert shrub rangelands may be roughly classified as songbirds, rodents and rabbits, reptiles, and predators (coyotes, bobcats, kit foxes, badgers, owls, hawks and eagles). Although some observations have been made of their abundance and activities, little information is available on ecological interrelations and impacts. Until these are better known, it appears prudent to aim at maintenance of somewhat natural populations of these native species to avoid serious disruption of ecosystems that have existed for long periods. Attempts to manipulate animal populations of salt-desert shrub ecosystems would seem ill-advised based on existing knowledge.

Recreation

In addition to the recreational values of wildlife, the vast and largely uninhabitated salt-desert shrub ranges provide unique areas for camping, rock-hounding, and enjoyment of the scenery or the solitude. Unfortunately, the wheels of offroad vehicles used to reach these recreational areas can destroy vegetation and damage the soil, often causing accelerated wind and water erosion. Regulations of recreational activities and repair of existing damage are serious management problems. Although a few badland and other scenic areas have been designated as State or National Parks, most of the salt-desert shrub rangelands are not esthetically pleasing to most people and, therefore, attract little attention for this purpose.

Soil Stabilization

Some wind erosion is normal in this arid region. For example, strong winds lift salts from the "sinks" or salt pan areas of some of the Great Basin valleys of interior drainage. In a number of these valleys, especially toward their northeasterly edges, sand accumulated in dunes from ancient deltas as Pleistocene lakes receded and disappeared, and some of these have not yet stabilized. For the most part, however, airborne particulate matter from the desert should be considered unnatural. Sands and sandy loams are readily erodable once the natural protection of vascular and nonvascular vegetation is reduced or broken up. The stability in many places is in delicate balance, readily damaged by grazing (trampling) animals and offroad vehicles, which injure the perennial plants, destroy microphytic soil crusts, and make the soils more susceptible to wind erosion.

On the sloping areas of salt-desert shrub rangelands, water becomes more important as an erosion agent. Examples of severe water erosion are the shale badlands of the Wyoming basin and Colorado Plateau. Because of the high erosion rates on many salt-desert areas, a number of measures such as contour furrowing, gully plugging, ripping, and pitting have been tried for reduction of runoff and erosion (Coltharp and West 1966). These treatments are aimed at increasing infiltration and decreasing overland flow. However, they are largely ineffective on salt-desert shrub areas because the shales are so impenetrable and the vegetal cover so sparse that more vegetation is destroyed than is encouraged (Gifford and others 1978).

Overland flow occurs during and following the more intense summer rainstorms. The severity and duration of a storm determine the amount of runoff. And, of course, a storm of an intensity to cause overland flow on a slope of some steepness may not be severe enough to yield runoff from gentler slopes. When sheet flow reaches the natural drainages, these flow as streams, tributary to the larger washes, which flow as rivers. On alluvial slopes, flow is rapid and has great sediment-load capacity and erosive power. Drainageways are dry most of the time, but their gravelly beds indicate bed movement at times of waterflow. They may revegetate during the years between discharges of rainfall runoff. They are a normal feature of deserts. The abnormal result of heavy rainfall is rilling of the upland areas between drainages. The ideal condition is sheet flow with a minimum of soil movement. This is possible where the stabilizers of the soil surface have not been injured by excessive use by hooved animals or vehicles. The pebbled pavement or the cryptogamic crust provides strength and surface irregularity to reduce velocity, cutting power, and particle-carrying capacity.

In the Colorado Plateau region, the parent material of some soils is salt-bearing shale, and erosion of the soil surface in deserts of that area raises the salinity of the runoff water as the salts are exposed and dissolved (Bentley and others 1980). Salinity of the water for users in the lower reaches of the Colorado River is a problem of international concern, so surface erosion in the deserts of eastern Utah, Wyoming, and Colorado is an important consideration in addition to the more obvious problems of reservoir siltation and site depletion by soil erosion.

As earlier discussed, soil is stable on range in good condition or with an upward trend. We emphasize again that livestock trampling can be a major cause of soil loss and sedimentation (Lusby 1970), and grazing must be carefully managed.

CONCLUSIONS AND SUMMARY

West (1982) and others suggest salt-desert shrub ranges will likely remain largely as wildlands with extensive management based on ecological restraints and economic constraints. Because of low grazing capacities, slow rates of recovery for existing deteriorated areas, and severe erosional problems in some locations, some livestock may be removed from certain ranges where they have historically grazed. On the other hand, implementation of improved management as recommended herein would possibly allow an accelerated upward trend in range condition and increased livestock production. Although inherent productivity is low, the vast area of salt-desert shrub rangeland contributes importantly to Western forage totals, and livestock grazing will probably remain as the principal use.

Because these rangelands will not readily accommodate agricultural or urban use, they will remain sparsely populated and, therefore, available for production of wildlife, for military uses, as a vast area for diluting air pollutants, as a source of minerals, and as open space for enjoyment of recreational activities. These uses and values should be properly integrated with livestock grazing to provide for improvement and conservation of a valuable resource that will be available to satisfy presently unforeseeable needs.

This publication is an overview of a vast amount of knowledge about the salt-desert shrub ranges. We have endeavored in the following summary to focus on the most important areas of that knowledge.

The Range and the Vegetation

Salt-desert shrub vegetation occupies some 40 million acres (16 million ha) of the Great Basin Desert. It is important for production of livestock and wildlife, for a variety of recreational activities, for soil stabilization, and as a resource reserve.

Salt-desert shrublands, like other western ranges, have been damaged by livestock grazing, construction of energy or transportation corridors, military operations, recreational practices associated with off-road vehicles, and surface mining. Restoration of desirable vegetation is needed on extensive areas.

Shrubby chenopods, commonly known as saltbushes, are the principal vegetal component of salt-desert shrub ranges. Shrubby composites and grasses are also important in certain areas.

Although numerous salt-desert shrub communities have been named, described, and studied, a usable classification system has not been developed.

Desert plants grow when temperature is satisfactory, but only if soil moisture is available at the same time. Because amount of moisture is variable from year to year and because different species flourish under different seasons of soil moisture, seldom do all components of the vegetation thrive in the same year.

Although direct revegetation is often needed, the different and harsh environment prevents the use of species and methods that have been successful for seeding other western ranges. Little evidence is available to support recommendations for extensive revegetation efforts in salt-desert shrub areas.

Weather and Soil

As the name implies, the salt-desert shrub region is arid. It is also relatively cold with warm (rather than hot) summers and with cold winters.

Animals, as well as plants, exhibit wide fluctuations in productivity from year to year, largely as a result of varying weather conditions.

Salt-desert shrub vegetation may be an indication of either climatically dry soils or physiologically dry soils.

Although salt-desert shrub vegetation and soils are obviously related, precise correlations are often lacking. Species and communities are apparently sorted out along physical, chemical, moisture, and topography gradients through complex relations that are not understood and are in need of further study.

Prevention of soil erosion is necessary to minimize site depletion, reservoir silting, and increase in water salinity, particularly in the Colorado River basin.

Condition and Trend

Because reliable judgment of condition and trend is essential to effective evaluation of range management practices, range managers should be able to identify the plants and their relative value as forage, to recognize differences among habitat types or sites, to understand ecological principles including patterns of and reasons for change, and to properly interpret change as a basis for adjustment in management prescriptions.

Information on condition and trend of salt-desert shrub ranges is largely limited to results of studies at the Desert Experimental Range in southwestern Utah. However, guides developed here can be broadly used by managers to make responsible judgments for a variety of similar plant communities or situations.

Criteria for judging range condition are amount of vegetal cover, relative abundance of desirable and undesirable species, vigor of good forage plants, and extent of soil erosion.

On salt-desert shrub ranges, trend in range condition is probably more easily judged than condition itself. Expressing the direction and possibly the rate of ongoing change, trend indicates the effect of current livestock grazing and suggests management actions for maintenance or improvement of range condition.

Downward trend is indicated by poor vigor of good forage species and evidence of severe grazing use such as presence of standing dead plants or their root stubs. Younger plants of desirable species are few in relation to number of young increaser or invader perennials. Upward trend, though more difficult to recognize, is improvement in quantity and quality of vegetation, provided that the soil is stable.

Wildlife and Range Pests

Increasing recognition has been given in recent years to range use as wildlife habitat. Associated plant communities such as sagebrush-grass and pinyon-juniper, as well as aquatic and riparian inclusions, are important as wildlife habitat and as recreational sites. Accordingly, they should be given special considerations in the development of management prescriptions.

Range pests such as insects, rodents and rabbits, and annual weeds can all have serious impacts, many of which are not well understood. Halogeton can be especially poisonous to sheep, and special grazing practices are necessary to prevent serious losses where this noxious weed occurs.

The Principal Use: Grazing of Livestock

Changes in salt-desert shrub communities are mainly caused by variations in climate and selective removal of plant parts by animals. Long-term studies at the DER have produced a wealth of information on effects on the vegetation of intensity and season of grazing by sheep.

Under heavy grazing, desirable forage species are often seriously injured or killed, whereas moderate grazing allows substantial increases in such desirables as black sagebrush and winterfat.

In addition to stocking rate, actual degree of use for a particular species is related to palatability and abundance. Even under a moderate stocking rate, use of a palatable species will be high if it is in short supply. Consequently, on a deteriorated range where a desirable species is poorly represented, its recovery is especially difficult.

Although vegetation response to intensity of grazing is important, season of grazing has a major influence on condition and trend.

Desirable species are apparently damaged by late winter grazing, heavy use, or a combination of the two. However, such practices as periodic rest, rotation of use, or adjustments in rate of stocking have allowed range improvement.

The "unit" system of grazing recommended by Hutchings (1954) should be followed for both sheep and cattle. This provides a continuing supply of high-quality forage and at the same time benefits the palatable shrubs by allowing regular periods of rest. This system also benefits pronghorn and other wildlife by always leaving some areas ungrazed until the period of new plant growth in the spring.

Although merits of various grazing regimens under the unit system have not been adequately compared, several combinations of rotation, deferment, and rest all seem to be beneficial, provided they allow periodic protection from grazing during the critical spring season of plant growth.

The percentage of current plant growth that can be removed by grazing without undue damage varies with the species and season of harvest. Use can be heavier in the cold part of the winter than in the spring, when plants are coming out of dormancy and beginning to grow.

Stocking must be based on species present and allowable use. Average use ratings from properly grazed ranges, often called proper use factors, serve as guides (see table 2). Stocking rates based on past use records also can serve as guides to grazing capacity.

Because of the livestock owners' difficulty in annually adjusting animal numbers to widely varying forage yields, and because it is well to have a margin of safety to avoid overstocking, basic stocking is recommended as 75 percent of the average forage—as distinguished from herbage—yield.

Because forage production is closely related to precipitation of the previous 12 months, stocking rate can be predicted well in advance of the winter grazing season (see fig 59).

In order to achieve proper use, an effort must be made to obtain even distribution of livestock over the entire allotment.

During the winter months, salt-desert shrubs are higher in protein, phosphorus, and carotene than associated grasses, which are superior only in energy yield. The shrub-grass mixture is generally adequate for supplying a balanced ration for livestock. However, evaluation of actual nutritive content is complicated by such factors as soil, site, stage of growth, and degree of weathering.

Although animal performance is sometimes improved by feeding supplements, similar results can be obtained from the unit system of grazing where animals are frequently placed on fresh forage.

As a general rule, supplements should be provided only at times of extreme emergency such as periods of deep snow when forage is inaccessible.

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This guide for range managers and users is a distillation of the most important research findings over the past 50 years. The research provides a strong scientific basis for planning and decisionmaking in the management of the salt-desert shrub rangelands of the Great Basin and Intermountain areas, which cover some 40 million acres. Much of the research took place in the USDA Forest Service's Desert Experimental Range in southwestern Utah.

KEYWORDS: salt-desert shrub rangelands, range management, Desert Experimental Range, vegetation, grazing, multiple use, Great Basin, sheep grazing, cold deserts

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

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