

inch deep failed to produce many seedlings in saturated or near-saturated soil. Poor aeration is perhaps the most obvious explanation, but undefined soil physical factors also may be involved. In a previous experiment, germinated seeds and fairly well-developed seedlings were found curled and compressed beneath a layer of soil at the same depth the seeds had been planted. The seeds had germinated, but the young seedlings did not have enough thrusting capacity to push through the soil. Investigations have not progressed to the point where combinations of soil and moisture that most restrict the upward growth of winterfat seedlings can be specified. The results do suggest, however, that clay was less of a barrier to an emerging seedling than either the sandy loam or loamy sand. Only in the clay soil did a reasonable number of seedlings emerge from the  $\frac{1}{4}$ -inch depth, and only in the clay was there fair emergence from seeds planted  $\frac{1}{8}$  inch deep in wet soil. Of course, soil characteristics other than texture may have affected the results.

Evidence from corollary investigations indicates that density of the germination medium, as well as aeration, probably influences the emergence of winterfat seedlings. Seeds were planted 10 mm deep in sand, perlite, and vermiculite held at  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and full saturation.

Practically no seedlings emerged in the sand, regardless of moisture content. Percent emergence in the less dense media was:

Saturation level	Perlite	Vermiculite
$\frac{1}{2}$	50	100
$\frac{3}{4}$	30	95
Full	10	80

### Conclusions

Shallow planting of winterfat seeds is important, regardless of soil moisture content or kind of soil. Fewer seedlings emerged in wet soil than in moderately dry soil, even when seeds were planted shallow. Soil texture, and possibly other soil characteristics, may affect emergence. Moreover, although the explanations are not clearcut, there were indications that (1) winterfat is somewhat sensitive to deficient aeration, and (2) dense soil, especially when it is wet, impedes emergence of winterfat seedlings.

Future investigations should be aimed at increasing knowledge about:

1. the inherent capacity of the seedling to break through the soil surface;
2. the effects of aeration on germination and seedling development; and
3. the physical characteristics of various soils, wet and dry, in relation to seedling emergence.

ious soils, wet and dry, in relation to seedling emergence.

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## MANAGEMENT NOTES

### Changes on a Sagebrush-Grass Range in Nevada Ungrazed for 30 Years<sup>1</sup>

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#### Highlight

Thirty years rest enabled a 20-acre tract of eroded sagebrush-grass range in northern Nevada to increase its vegetative cover in all life forms. The cover of perennial forbs increased the most, 85%. Thurber needlegrass increased 7 fold. Only annual forbs and locoweed declined. Bluebunch wheatgrass was reestablishing naturally in favored spots. Newly cleared and seeded range outside the enclosure produced three times as much grass forage as produced after long rest without clearing.

Personnel of the Grazing Service and Forest Service selected a site for range improvement studies

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in a big sagebrush-Sandberg bluegrass (*Artemisia tridentata*-*Poa secunda*) type in Paradise Valley, Humboldt County, Nevada, in 1939. A 20-acre tract was fenced on federal land at 4,700 feet elevation below the boundary of the Humboldt National Forest. It lies in Section 34, T 42 N, R 39 E near the Singas Creek Road two miles west of its junction with Highway 8B. The enclosure was assigned to the Intermountain Forest and Range Experiment Station as a responsibility of the Santa Rosa substation.

Seeding trials in 1940-44 showed the possibility of establishing desert wheatgrass (*Agropyron desertorum*) and beardless bluebunch wheatgrass (*A. inerme*). These species yielded 133 lb./acre and 625 lb./acre, respectively, in their sixth year. Eleven others failed to establish and survive, thereby reflecting the harshness of the environment. Only one-fourth acre in a corner was disturbed by these plots.

The woven-wire fence remains sound but was not designed to exclude rabbits.

Lying near Singas Creek, a permanent stream, this range has been grazed by cattle, sheep, and horses since ranching began in the 1860's. The Santa Rosa Mountains, towering immediately on the west, have provided the summer forage, while the ranches below have grown hay for about three months of winter feeding. Consequently, the foothill and valley ranges have supported the stock for 5-6 months in spring and autumn.

Two local range managers looked at the allotment that includes this enclosure in 1951 and wrote of it as follows:

"There are many acres of sick land throughout the western states—lands in critical condition. The history of use of these ranges is similar to many other comparable regions throughout the West: early settlement, rapid development of livestock industry and influx of many nomad grazing herds. These nomad herds, lacking a base of operations stayed on the ranges as long as weather permitted. This use coupled with the grazing herds of the bona fide rancher and settler, together with game herds increasing under protection by law, rapidly damaged or denuded much of the grasslands area of Paradise Valley. The Paradise C & H allotment on the forest and the adjacent Paradise Unit on the Bureau of Land Management lands is one of those areas which had not responded to ordinary good management practices. Flash floods, soil and vegetation losses, decrease in perennial grasses and the spread of halogeton, sagebrush and other undesirable plants were still progressing. The range trend was still downward. These lands had been early denuded of palatable forage over the years and the grazing capacity was estimated to be 20 acres or more per AUM. Sagebrush and halogeton had invaded this area in considerable quantities." (Cloward and Fulwider, 1955).

An area lower on the slope than the Singas Creek enclosure but clothed by similar vegetation was classified as loam and placed in the Brown Great Soil Group. The hardpan was at 1½ to 2 feet. Rocks were fewer than within the enclosure. Other characteristics at 1-3" depth were: as to texture—gravel 6%, sand 38.3%, silt 47.2%, clay 14.5%; as to reaction—pH 7.2; as to electrical conductivity  $0.46 \times 10^3$ . Organic matter was 0.96% and total nitrogen 0.11% in the surface 6 inches (Eckert et al., 1961). The soil of the enclosures is obviously well within the chemical and physical parameters known to be suitable for halogeton (*Halogeton glomeratus*) (Robocker, 1958) which was not observed in the Valley in 1939.

#### Measurements Made

Forty circular temporary plots were located along 5 transects. Plot area was 100 sq. ft. They were

Table 1. Change between cover (%) estimates at Singas Creek Enclosure, Paradise Valley, Nevada 1940 and 1970.

Species	1940	1970	Change
<b>Grasses</b>			
Crested wheatgrass	0	0.002	—
Sandberg bluegrass	0.843	0.903	+ 7.7
Squirreltail	0.194	0.548	+ 182.3
Thurber needlegrass	0.050	0.413	+ 726.0
All perennial grasses	1.087	1.866	+ 71.7
Cheatgrass brome	0.215	0.297	+ 38.1
<b>Forbs</b>			
Locoweed	0.155	0.038	- 75.5
Woolly phlox	0.372	0.778	+ 109.1
Other perennial forbs	0.189	0.507	+ 168.2
Other annual forbs	0.336	0.006	- 98.2
<b>Shrubs</b>			
Big sagebrush	4.425	7.781	+ 75.8
Smooth horsebrush	0.078	0.128	+ 64.1
All shrubs	4.503	7.909	+ 75.6
<b>Total vegetal cover</b>			
Height sagebrush	25.0"	21.9"	- 12.4
No. sagebrush/100 ft <sup>2</sup>	—	9.4	
<b>Surface</b>			
% rock	1.55	1.08	- 30.3

spaced at 100-ft intervals. One transect was exactly on the long axis, the other four paralleled the sides and ends at a distance of 100 ft.

Cover characteristics of these plots were recorded by the writer, using the square-foot density method of Stewart and Hutchings, 1936. The work was done on July 20-23, 1940.

Plots were relocated by measurement from original markers on the fence and cover was re-estimated by the same technician and method on July 23-24, 1970.

Range bordering the enclosure had been seeded to crested wheatgrass in 1968 by the Bureau of Land Management. It was nearly mature but as yet ungrazed. As a sidelight, a transect of fifteen 9.6 sq. ft. plots was clipped in the crested wheatgrass for comparison with a parallel set within the enclosure.

#### Changes Observed

There had been a general increase of over 60% in vegetal cover. Only locoweed (*Astragalus arrectus*) and miscellaneous annual forbs decreased (Table 1).

Only three perennial grasses were present both years and they increased in basal cover by 72%. The annual cheatgrass brome (*Bromus tectorum*) increased 38%.

Thurber needlegrass (*Stipa thurberiana*) multi-

Table 2. Comparison of production by forage grasses on protected, brush-grass range and cleared, seeded range in lb./acre of air dry matter.

	Native range, 30 years protection	Reseeded
Perennial grasses	179	858
Annual grass	20	68
Total	199	926
% of seeded	22	100
% of protected	100	465

plied its basal area over seven times during the 30 years while squirreltail (*Sitanion hystrix*) nearly trebled. Sandberg bluegrass made little change.

Increase in perennial forbs as a group was also spectacular, 85%. Woolly phlox (*Phlox hoodii*) more than doubled its ground cover.

The two shrubs increased in canopy cover in about the same degree as the perennial grasses, 76%. At the same time the average height of sagebrush declined three inches.

Several species were present only as traces in the plots and are omitted from specific comparison in Table 1. They are wild onion (*Allium* sp.), sego lily (*Calochortus nuttallii*), thistle (*Cirsium* sp.), wild lettuce (*Lactuca* sp.) and foothill death camas (*Zygadenus paniculatus*). "Other perennial forbs" in Table 1 also include several natives so scarce in 1940 that they were not estimated by species. Though more abundant in 1970 they were again consolidated. This group includes false yarrow (*Chaenactis douglasii*), tapertip hawksbeard (*Crepis acuminata*), fleabane (*Erigeron concinnus*), desert parsley (*Lomatium* sp.), stony-ground lupine (*Lupinus saxosus*), and aster (*Macheranthera leucanthemifolia*). Density of sagebrush in 1970 was 9.4 plants per 100 sq. ft. Counts were not made in 1940.

Crested wheatgrass in one plot represented the volunteers from plots seeded in 1940. Halogeton, now abundant in the Valley, appeared in three plots much suppressed. Organic litter, including moss, not estimated in 1940, was estimated as 10.2% in 1970.

Exposed rock surface was diminished nearly one-third by the increase in organic cover. The exposed surface soil, inside but not outside of the enclosure, consisted of a vesicular crust which readily compressed underfoot.

Production by the new crested wheatgrass was conspicuously more than across the fence in the long-protected vegetation. Differences in dry matter yield as the average of 15 plots are presented in Table 2. The newly seeded range is producing over three times as much forage as that protected for a long period. The forage is also more accessible.



FIG. 1. These *Agropyron spicatum* plants appear to be in the vanguard of a returning population.

### Discussion

Data obtained by the square-foot density method are supposedly more consistent when repeated by the same technician. However, in this instance, safeguards are lacking against changes in judgment that could occur over the 30-year interval. Care was used to follow the same technique.

It is probable that forbs and ephemerals were under-estimated in 1940 and 1970 because of their advanced phenology. July of both years was abnormally dry. However, May-June precipitation in 1970 was 4.24" compared with 0.82" in 1940. Probably the difference in vegetal cover was influenced thereby.

Concomitant increase in cheatgrass brome and decrease in exposed rocks may have resulted from much higher spring precipitation in 1970. Perennial species as well doubtless responded by increasing cover during the wet May and June of 1970.

The appearance of vigorous bunches of bearded bluebunch wheatgrass (*Agropyron spicatum*) in swales in 1970, though not shown in the plot data of Table 1, is believed to be a significant indicator of upward trend (Fig. 1). It suggests also that this excellent forage species was originally prominent on the site.

The increase in perennial forbs and decrease in annual forbs may reflect a continuing process of secondary succession in which the former balance among life forms is being restored since cessation of sheep grazing. Doubling in area of the mat-forming phlox is ecological salve for a sore soil.

Partial disappearance of rocks indicates a trend toward better surface protection.

Thurber needlegrass, and to a lesser degree, squirreltail, behaved as decreasers by increasing under protection. The concept of Sandberg bluegrass as an increaser was not shaken by its behaviour here.

Height reduction of 3 inches in sagebrush may result from demise of taller plants without replacement, or an increase in density with younger age classes present and suppressed by competition. The latter appeared to be the better explanation.

While the plot data indicate that forage cover on a depleted sagebrush range can be improved by long rest, obviously superior results can be obtained more quickly by the now familiar one-two punch, brush control and seeding. For best returns this should be followed by a well-planned yet flexible grazing system.

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## VIEWPOINTS

### Relevance of the Population Explosion to Management of Sparsely-Populated Lands

The human population problem has been the subject of considerable investigation. Apparently the optimum carrying capacity for mankind on earth has been exceeded. Problems are occurring that seem to be the result of people making too many demands on the resources of a finite management unit—the earth.

If it were possible to support our present human population with a satisfactory standard of living, there would be little need for concern. But in fact more than 1 billion people on the earth are either undernourished or malnourished.<sup>1</sup> In our own country food is not yet the major problem, but open space is dwindling and parks are crowded; noise, pollution, ugliness, and general unrest are on the increase; and resources are becoming more difficult to acquire without unfortunate consequences. By the year 2000 the U. S. could have another 100,000,000 people if current trends continue.<sup>2</sup> The demands of these additional people would be magnified by still greater affluence and resource consumption per capita.

What do these trends in our country and the world mean to the manager

<sup>1</sup> Ehrlich, P. R. and A. H. Ehrlich. 1970. *Population, Resources, Environment: Issues in Human Ecology*. W. H. Freeman and Co., San Francisco. 383 p.

<sup>2</sup> Colorado Institution on Population Problems. 1969. *World population growth: the explosion ahead*. 555 Petroleum Club Building, Denver, Colorado. (Pamphlet)

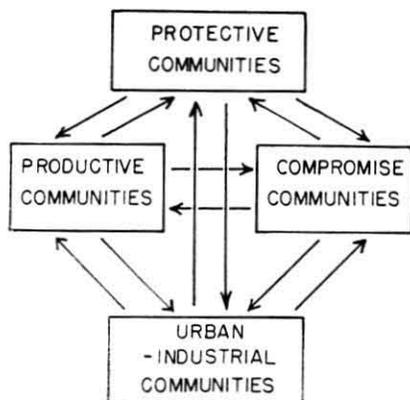


FIG. 1. Four basic communities or environments in the landscape; the arrows suggest interaction. Population pressure will result in the conversion of more of the landscape to productive and urban-industrial communities. Modified after Odum (1969).<sup>3</sup>

of our sparsely populated lands? This question can be considered by focusing on the concept of landscape diversity.

#### Diversity in the Landscape

Landscape diversity is the number of different communities in the landscape. To evaluate landscape diversity, it is first necessary to classify communities; several classification systems are possible, but I will use a scheme suggested by Odum<sup>3</sup> (Fig. 1). The community types that Odum lists are 1) protective communities, e.g. wilderness, smaller natural areas, parks, wild rivers; 2) compromise or multiple-use communi-

<sup>3</sup> Odum, Eugene P. 1969. The strategy of ecosystem development. *Science* 164:262-270.

ties, e.g. much of our forest and range land; 3) productive communities, e.g. agricultural land and perhaps strip mines; and 4) urban-industrial communities. Odum suggests that our civilization here in America, and in the world, depends on a certain proportion of all four community types. Obviously the categories are very general and would apply to a large landscape unit, usually not just a single watershed.

Though initially Fig. 1 may appear very general and simplistic, I believe that it deserves serious consideration and it does suggest some practical implications when considered in the context of the population problem. For example, as population pressure increases in the country as a whole, we can expect that urban-industrial communities will increase in the west, on the one hand reducing the amount of productive land, but also demanding more production. To meet this production demand, rangeland will be used much more intensively, converted to agricultural land with irrigation, or consumed by mining activities to provide mineral resources. With more demands for specific resources, compromise multiple-use communities such as rangeland probably will have a lower priority and will give way to productive communities; and protective communities will be either reduced in area or even more crowded to the extent that they can hardly be classified any longer as protective. It seems clear that the trend with more population pressure will be toward urban-industrial and productive communities, with a decline in the compromise and protective communities that are also in demand, but which probably will not have priority.