The fact that fertilization on our rangelands increases root production also shows up in a different way during dry years. During a drought, fertilized rangeland often does not produce significantly better than does unfertilized. In studies at the Dickinson, North Dakota Experiment Station during 1976, a year of lower than normal precipitation, fertilized crested wheatgrass (*Agropyron desertorum*) and native pastures demonstrated a much greater decline in production than did the unfertilized pastures (Nyren and Whitman 14). The unfertilized crested wheatgrass showed a slight increase over 1975 production levels. While no data were obtained on soil moisture levels it is possible that the increased vigor of the root system of the fertilized pastures had significantly reduced soil moisture reserves. Lacking the normal winter and spring recharge, these pastures had less soil moisture reserves than did the unfertilized pastures. The unfertilized pastures lacked root system volumes to extract as much moisture during the 1975 season. Other research at Dickinson tends to enforce this idea. Goetz (7) found that plots fertilized with 67 lb N per acre annually had less available soil moisture following the growing season than did plots receiving no fertilization. Fertilizer applied during dry years may not be used, but this added N will remain within the soil profile and be available for plant use when adequate soil moisture reserves improve.

(This article will be concluded in the next R. At that time we will discuss effects of fertilization on grazing seasons, species composition, and improving overgrazed ranges. It will also carry a summary, along with a listing of the 23 pieces of cited literature).

Soil Moisture and Grass Growth in Northern Nevada in a Drought Year

Bruce A. Roundy, R.E. Eckert, Jr., and R.A. Evans

Concern over possible drought promoted the monitoring of soil moisture in northern Nevada from March through June 1977. Moisture was measured by gypsum soil-moisture blocks buried in the soil at depths of 6, 12, and 24 inches. These blocks have essentially the same moisture content as the surrounding soil. The electrical resistance measured in the blocks can be converted to bars of tension, or the force with which water is retained by the soil. As the soil dries to a point near 15 bars of tension, plants are generally unable to extract water from the soil, and soil-moisture is termed "unavailable" to the plants. Under this condition, some plants permanently wilt, others continue to grow very slowly, and others go into dormancy and stop growing. Moisture held at ⅓ to 15 bars of tension is generally available for plant use.

Spring-soil-moisture directly affects spring and summer production of range forage in Nevada. The soil should have available moisture in the spring when temperatures are warm enough to permit rapid growth of plants. The availability of soil-moisture in the spring depends primarily on the amount of precipitation in the late fall and winter, the spring, or both. In winter, when evaporation and water use by plants are lowest because temperatures are low, dry soils are generally recharged with water from melting snows. Spring rains may provide additional recharge if they fall in sufficient quantity and at a rate slow enough to infiltrate the soil and percolate to the root zone.

Soil-moisture was monitored at 30 sites in 14 general areas from east to west across northern Nevada in 1977. The sites are on sagebrush/grass and cheatgrass ranges in the foothills and valleys and are past range research locations. Soil-moisture data from 1964 to 1969 and 1975 to 1976 for 22 of the sites in 11 areas were available for comparison with the 1977 data.

Precipitation varies greatly from year to year and from site to site within a particular year, so the availability of soil-moisture in spring and summer is quite variable. However, some general patterns of precipitation and soil-moisture availability were evident. The springs of 1964, 1965, 1967, and 1975 had from less than an inch to over 2 inches more precipitation than normal (U.S. Department of Commerce, 1964-69, 1975-77). Also, the winters preceding these springs generally had above-normal precipitation. Soil moisture in these years was available throughout the soil profile from March through June, and most sites had available moisture in some part of the profile in July. This availability pattern is representative of the wetter years, and would be expected to contribute to high forage and seed production because moisture is available for plant growth through July. The springs of 1966, 1968, and 1969 had precipitation ranging from an inch below normal to normal, and the winters preceding them were moderately dry (about 1.5 inches less than normal precipitation in 1966 and 1968) to moderately wet (about 1.5 inches more than normal precipitation in 1969). Generally, soil-moisture in these years was available throughout the soil profile from March through May and was available at depths below 12 inches in June. Moisture was unavailable throughout the profile in July. This pattern may be representative of dry to average years. In general, plant growth would be expected to end sooner in these years than in wetter years, and forage production from annual grasses such as cheatgrass would probably be lower than in wetter springs.

The spring of 1977 was preceded by an extremely dry winter in

This study was a result of the cooperative investigation of U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, and the Agricultural Experiment Station, University of Nevada, Reno.
The authors are range scientists, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, Renewable Resources Center, University of Nevada, 920 Valley Road, Reno, Nevada 89512.

Table 1. Maximum leaf length (inches) of grasses under three soil moisture patterns during the spring of 1977 in Nevada.

Grass	Wet areas	Dry areas with spring rains	Dry areas without spring rains
Native perennials	9	6	5
Crested wheatgrass	18	13	9
Cheatgrass	12	4	4

which the precipitation was more than 3 inches below normal in northern Nevada. Rains provided slightly above-normal precipitation in May and June. Three soil-moisture patterns were apparent among the 14 areas monitored. Five areas were comparatively moist; moisture was available throughout the profile through May, and generally was available in some part of the profile in June or July. Perennial and annual grasses had good seed production, and their leaf growth was greater in these wetter areas than in the drier areas (Table 1).

The remaining nine areas had available moisture only in part of the soil profile in March, reflecting limited winter recharge. This moisture generally became unavailable in April, especially in the surface soil. Seven of these areas received rain in May and June, and moisture was then available again at a depth of 6 inches until the end of June. Perennial grasses produced seed on all but one site in these seven areas, but total leaf growth was about 4 inches less than that on the wetter areas. Fall-germinated cheatgrass on one cheatgrass-dominated site with this moisture pattern was dead by the time spring rains came, and very little spring germination occurred after the rains. Fall-germinated cheatgrass on the sagebrush sites with this moisture pattern had less leaf growth than that on the wetter sites and had limited spring production.

The other remaining areas had limited winter recharge and did not receive moisture from spring rains. Perennial grasses produced seed on 8 of 10 sites in these areas but leaf growth was less than that of grasses in dry areas receiving spring rains. The condition of cheatgrass in these areas was similar to that of cheatgrass on the areas receiving surface-moisture recharge from May and June rains. This observation indicates that spring rains generally were too little and too late for good cheatgrass production in the drier areas.

In summary, the lack of winter precipitation resulted in poor soil-moisture recharge in 1977. Soil-moisture in past years has generally been available throughout the soil profile through May or June. In 1977, however, moisture was available only in part of the profile until May or June in most of the areas. May and June rains extended the period of available moisture in the wetter areas and recharged the soil surface moisture in the drier areas. These rains permitted the extended growth of perennial grasses, but did not appear to permit recovery of cheatgrass production in the drier areas.

The value of perennial grasses, rather than cheatgrass, as a spring forage base on sagebrush ranges was especially apparent in the 1977 drought year. While cheatgrass must rely on surface soil moisture to germinate and grow each year, perennial grasses with well-developed root systems can begin growth on limited subsurface moisture and take advantage of late spring rains like those that fell in 1977. Conversion of cheatgrass-dominated areas to perennial crested wheatgrass would help ensure forage production and watershed protection in drought years. ●