burns may become more and more an opportunity.

Especially in the good rainfall years, wind erosion on rangeland becomes an easy mark for complacency. Keep in mind that it has been during the major, prolonged droughts of our century that we realized the most severe wind erosion. These same droughts helped increase water erosion by contributing to a reduction in herbaceous plant cover and stimulating brush invasion. The next drought is always just around the corner. It will seem to come even sooner and the dust will blow even harder if we fail to allow for its liklihood in management plans.

Lastly, a word about grazing systems. Many have worked long and hard in this area over the years. Today, southwestern New Mexico ranchers are more receptive than ever to improved grazing management options. None have more directly at stake when it comes to taking care of the land than those who make their living there. Some approach to both routine deferment and properly timed grazings in the management plan is important in almost all cases, but no one "system" does the job everywhere for every one. It is extremely important that our profession does not quibble when it should be providing solid support. Our options for using and conserving a wonderfully productive resource may escape us if we fail.

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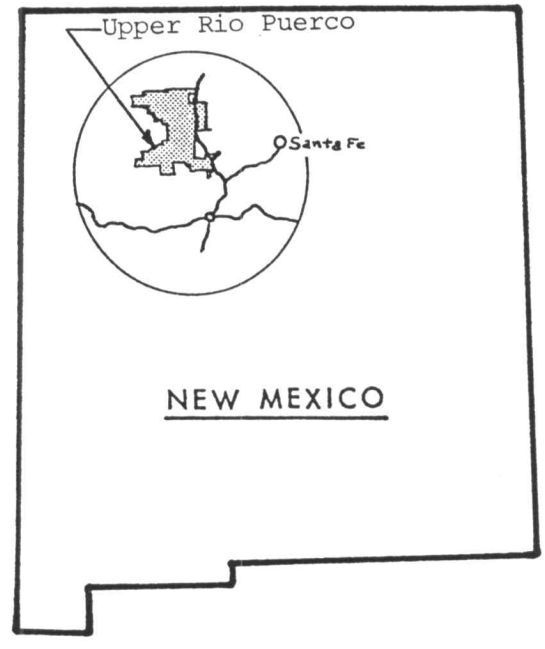
The Sagebrush/Grasslands of the Upper Rio Puerco Area, New Mexico

Dwain W. Vincent

The upper Rio Puerco drainage in New Mexico, may have the farthest south and east population of the big sagebrush/grass ecotype in the United States. This ecotype, covering about 164 square miles, is found mainly in the upland valleys with pinyon juniper woodlands on ridges, mesas, and mesa side slopes. The area extends from the Continental Divide west of Cuba, N.M., southward approximately 31 miles to the village of San Luis, N.M., west of the Rio Puerco. Elevations range from 6,300 to 7,500 feet. This area is described broadly as the southeast portion of the Colorado Plateau.

Big sagebrush is well adapted to the climate, topography, and soil conditions in the area. It has a competitive advantage on the more xeric sites because of its ability to endure drought and root development into the water table (West 1978). The sagebrush root system is generally more vigorous and hardy than that of most grasses, but the grass shoot is more vigorous and quicker to grow than the sagebrush shoot (Beetle 1960). In the absence of drought, certain grass shoots, such as western wheatgrass and alkali sacaton, may shade the sagebrush shoot enough to kill and simply out-compete it.



Once big sagebrush becomes established as the dominant species, it stabilizes succession for long periods (Evans et al. 1978). It is not known how long big sagebrush will remain dominant, because preserved relic areas that are comparable to the majority of sites currently under sagebrush dominance are difficult to find (West 1978). Big sagebrush may have a life expectancy of over 150 years (Ferguson 1964). Much of the sagebrush in the upper Rio Puerco is over 50 years old, even in areas where livestock are excluded.

Historical Impacts

Pollen of *Artemisia* has been identified from the Miocene (Beetle 1960). During the pluvial intervals of the Pleistocene Epoch, much of the area presently dominated by sagebrush was presumed covered by woodland. Sagebrush occupied a seral stage in the middle and late Tertiary woodland flora. A general climatic warming began in the Holocene Epoch starting 10,500 years ago. The trees retreated extensively, particularly during the dry and hot intervals approximately 4,000 to 7,500 years ago (West 1978). With the restriction of the woodland in the late Cenozoic, these sagebrush/grass communities gradually became climax over areas formerly dominated by woodland (Young et al. 1979).

Large herbivores that became extinct in New Mexico during the late Pleistocene, such as camels, ground sloths, and mammoths, were browsers and may have been a factor in keeping brush density at lower levels. These browse niches are now gone and no animals currently utilize big sagebrush sufficiently to keep its range and density in check (Martin 1967).

Beginning in the 1750's, Spanish settlers grazed sheep, goats, and cattle on a yearlong basis in the Rio Puerco area. The Spanish system of livestock production had evolved in a Mediterranean environment and the semiarid climate of the Rio Puerco proved its demise. As livestock production expanded, periodic droughts and severe winters forced the livestock producers to produce hay winter feed as a supplement for livestock (Young et al. 1979). The necessity for winter feeding still exists in the upper Rio Puerco.

The concentration of large herbivores by the Spanish in the sagebrush/grass communities had a spectacular impact. After a few decades of intensive, continuous livestock grazing by ever-increasing numbers, the potential of the sagebrush/grass ecotype to produce sustainable forage for large livestock numbers was gone. The native perennial grasses and forbs were greatly reduced (Young et al. 1979).

The peak of livestock numbers in the area occurred in 1870, 100 years after Spanish settlement. After World War II, most ranchers in the area converted from sheep to cattle.

We can infer that prior to the 1750's, productivity in the Rio Puerco sagebrush/grass communities was optimum. We can also speculate that the original sagebrush/grass communities were relatively open stands with a productive understory of grasses and forbs. Not all sagebrush/grass communities were in equilibrium with their environment before 1750. Seral communities existed in pristine as well as exploited environments (Young et al. 1979). Wild fires almost certainly decreased big sagebrush populations and insects may have defoliated large areas. It is impossible to say how much of the sagebrush/grass ecotype in the upper Rio Puerco may have been in a seral status under pristine conditions. The sagebrush/grasslands were never true grasslands because of the dominance of big sagebrush. If they were true grasslands, the understory grasses and forbs should have returned under relaxed grazing pressures. Heavy, continuous grazing during the short growing season caused rapid deterioration of the sagebrush understory. The native herbaceous species did not evolve under centuries of heavy ungulate grazing as they did on the shortgrass plains in eastern New Mexico.

Reduction of livestock numbers following the Taylor Grazing Act in 1934 did little to reverse the degraded changes on most sites. Therefore, range managers have relied on mechanical or chemical methods of reducing big sagebrush since the 1950's.

Climate/Phenology

Most precipitation on the Rio Puerco area occurs during summer convection storms (July, August, and September). Periodically there are wet winters with significant snowfall. The mean annual precipitation is 10.5 inches with ranges of 8 to 16 inches. Average annual temperature is 48° F with extremes of 100 F to 40° below zero. The frost-free season ranges from 100–150 days. Big sagebrush normally grows best where winter precipitation equals or exceeds summer precipitation (Dahl et al. 1976).

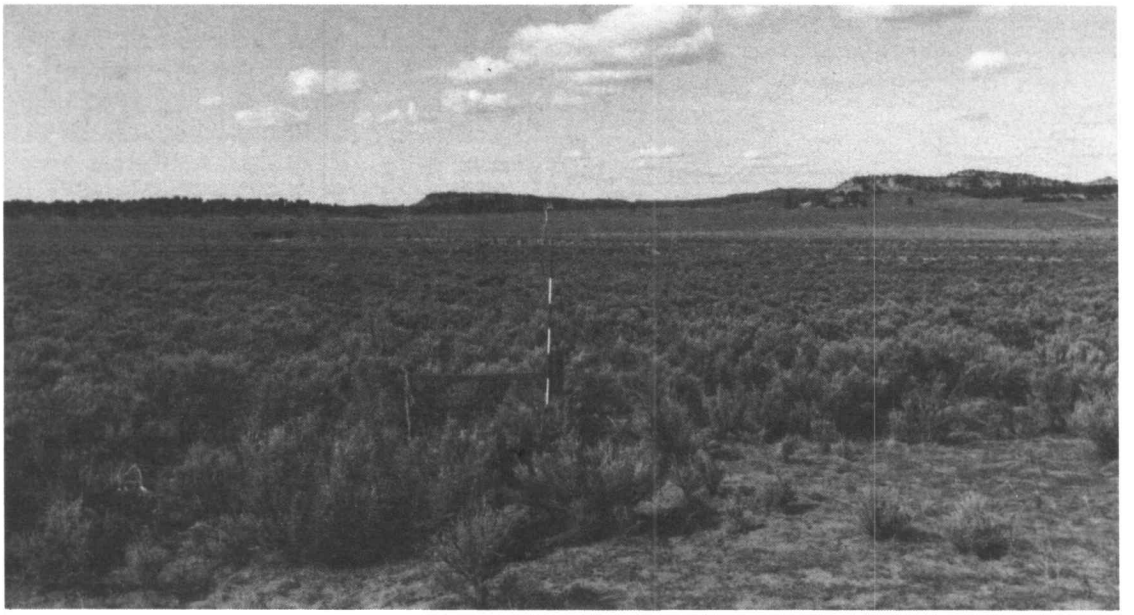
Soil moisture from snow during the fall, winter, and early spring provides the cool-season grasses associated with big sagebrush moisture for spring and early summer growth. Most understory cool-season species in the big sagebrush/grass ecotype of the upper Rio Puerco begin growth during the first 10 days of April (Dahl et al. 1976). Peak leaf height occurs from mid-May to late June and seed heads mature by early to mid July.

Big sagebrush starts growth in late March to late April. Seed heads develop in July, but flowering is delayed until September following fall regrowth in late August. Seeds are shed in October and November (Dahl et al. 1976). *Artemisia* has become specialized for wind pollination, with heads much reduced and aggregated into compound inflorescenses. Another feature of big sagebrush is the formation of layers of cork between the growth rings of xylem. This is an adaptation to severe cold or drought conditions (Stebbins 1971).

Soils

The soils of the upper Rio Puerco sagebrush/grass ecotype are classified as Mesic. The subgroup includes Typic Torripsament, Mollic Haplargid, Mollic Camborthid, and Entic Haplustolls. The orders are Entisol, Aridisol, and Mollisol. The great soil groups are Regosal, Brown, Alluvial and Lithosols.

The soils have developed from a layered sandstone-shale parent material formed by periodic flooding during the Cretaceous era. The soils which have developed range from clay loams to sandy clay loams and are generally very fertile, but have become degraded. Sagebrush/grass rarely occurs on soil depths of less than 10 inches in this area, although individual plants may be found in isolated cracks and crevices. The soils of drainage bot-



toms usually exceed 36 inches and have a sagebrush dominant aspect (USDA, USDI, NM Agric. Expt. Sta. 1968).

Characteristics and Uses of Big Sagebrush

Big sagebrush or basin sagebrush is from the family Asteraceae; tribe Anthemideae; and genus *Artemisia*. Its name comes from the wife of Mausolus, king of Caria, and she, in turn, was named after Artemis, the Greek goddess of the moon. The species name, *tridentata*, refers to the 3-toothed leaves (Vines 1960). It is a native, perennial, evergreen to late deciduous shrub or small tree that grows up to 6 meters tall. Taxonomic characteristics can be found in two subspecies, *A. tridentata tridentata* and *A. tridentata wyomingensis* found in the Rio Puerco area.

The wood makes a hot fire and the brittle branches have been used for thatch or temporary sheds. The shrub's pollen causes hay fever, and an extract is used as a diaphoretic, antiperiodic, or laxative (Vines 1960). Its wood smoke is so pungent that the Indians used to steep themselves in it to help neutralize the effects of an encounter with a skunk (Elmore 1976). Sagebrush in the Rio Puerco area is eaten by small animals and browsed by mule deer, pronghorn, cattle, elk, and domestic sheep.

Big sagebrush is relatively unpalatable and uses moisture, nutrients, and space that could produce forage for wildlife and livestock. It is high in protein, but also high in volatile oils. The oils in big sagebrush inhibit the activity of rumen microflora. Because of the oils in the leaves, big sagebrush is much less palatable than the grasses in summer, but may be used by livestock in the winter. For cattle, big sagebrush will be little utilized at any season if given a choice. Black sage is slightly more palatable for cattle.

The root system of big sagebrush consists of both a long tap root and an extensive network of shallow roots. The long tap root enables the plant to reach the deeper water reserves unavailable to herbaceous species, while the shallow roots are able to effectively capture moisture during high intensity, short duration, summer convection storms. Big sagebrush leaves vary in size, depending upon soil moisture when growth begins. This gives it a distinct advantage over other species present in the community.

Species Composition of Big Sagebrush/Grass Communities

Francis (1986) found the following major species in seven big sagebrush/grass communities. The mean importance value for each species is listed which is the sum of the relative cover, density, and frequency for each species.

Species	Mean Importance Value
Blue grama *Bouteloua gracilis*	.7866
Sand dropseed *Sporobolus cryptandrus*	.5516
Alkali sacaton *Sporobolus airoides*	.4373
Galleta grass *Hilaria jamesii*	.4351
Big sagebrush *Artemisia tridentata*	.4074
Western wheatgrass *Agropyron smithii*	.2723
Broom snakeweed *Xanthocephalum sarothrae*	.2065
Bottlebrush squirreltail *Sitanion hystrix*	.1230
Indian ricegrass *Oryzopsis hymenoides*	.1195

Management

We do not have historical records that tell us what the potential vegetation was in the sagebrush/grass ecosystem. What we must now manage is the existing vegetation based on the productivity or potential of the current landscape. We must interpret these seral communities and keep them in an equilibrium with a "desired plant" community for the site.

Management goals for the upper Rio Puerco sagebrush/grass communities may be best directed toward watershed stability. To accomplish this, it is necessary to produce a more dense herbaceous cover to hold the soil in place, increase infiltration and resistance to flow. Most

sediment loss from degraded big sagebrush occurs in the interspaces between sagebrush plants (Blackburn 1975). An increased herbaceous interspace cover will reduce runoff and erosion, increase water infiltration, reduce sediment transport, and improve water quality. In order to produce a more dense herbaceous cover, the amount of big sagebrush should be reduced.

The reduction of big sagebrush will also improve the wildlife habitat diversity. Sagebrush/grass communities provide critical winter range for mule deer and pronghorns in the upper Rio Puerco. Deer cannot survive on sagebrush alone but do utilize up to 50% in their diet. The reduction of big sagebrush will also improve the quality of sustainable forage for livestock (McEwen & DeWeese 1987).

Big sagebrush/grass communities produce a range of forage production. Based upon eight years of production data, three forage values for sagebrush/grass communities in the upper Rio Puerco were calculated (Francis 1990). The usable pounds of air dry forage per acre for cattle ranged from a high of 148 pounds to a low of 65 pounds, with a mean of 107 pounds.

Grazing management alone in the big sagebrush/grass ecotype will not improve the range condition or watershed condition in any reasonable time period. It may only hold the area in a static condition. Grazing management will be more effective in those sagebrush/ grassland communities that are in a mid to high seral condition. In the upper Rio Puerco, livestock grazing should occur during the non-growing season, allowing herbaceous understory to maintain its vigor. For degraded sagebrush/grass communities dominated by big sagebrush, with little or no perennial grass and forb understory, deferment and rotation for range improvement is not realistic (Laycock 1978, Young et al. 1979).

Grazing systems that result in heavy use of herbaceous understory during the growing season, even for a short period, have a chance to cause deterioration. Because the sagebrush is not utilized, it responds to reduced competition from the deterioration of herbaceous species and becomes more competitive (Laycock 1987).

Most sagebrush/grass communities in the upper Rio Puerco produce only 10–15 percent of their potential forage. Removing livestock from these degraded sites for up to twelve years makes only minor changes in the sagebrush cover relative to continued cattle use (Dahl et al. 1976). In areas of low growing-season precipitation, even moderate use of perennial herbaceous species may place them in a severe competitive disadvantage over the non-palatable and well adapted big sagebrush.

The most effective brush control treatment in the upper Rio Puerco has been the application of herbicide. A few areas have enough understory to carry a fire, and prescribed burning should be used where practicable; however, the major advantages of herbicide control are that it will maintain the desirable, native grass species, retain the integrity of the ecosystem, and can be applied with little or no soil surface disturbance (Lancaster et al. 1987).

If big sagebrush is a natural part of the community, it will eventually return. The time required for big sagebrush to return will depend on the subspecies of sagebrush, the management of the area, and climatic factors (Laycock 1978).

Range managers will have to battle succession in the Rio Puerco watershed for many years to come in order to maintain the desirable plant communities where big sagebrush dominates the sites.

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