tices may be obtained from the Nevada Division of Forestry or the Shrub Sciences Lab.

Literature Cited

Alderfer, J.M. 1977. A taxonomic study of bitterbrush (*Purshia tridentata* [Pursh] DC) in Oregon. M.S. Thesis, Oregon State Univ., Corvallis.

Edgerton, P.J., Geist, J.M., and W.G. Williams. 1983. Survival and growth of Apache-plume, Stansbury cliffrose, and selected sources of antelope bitterbrush in Northeast Oregon. p. 45-54. *In:* Proc., Research and Management of Bitterbrush and Cliffrose in Western North America. Tiedemann, A.R., and K.L. Johnson (compilers). USDA Forest Serv. Gen. Tech. Rep. INT-152.

Nord, E.C. 1965. Autecology of bitterbrush in California. Ecol. Monogr. 35:307-334.

Welch, B.L., S.B. Monsen, and N.L. Shaw. 1983. Nutritive value of antelope and desert bitterbrush, Stansbury cliffrose, and Apache-plume. p. 173-185. *In:* Proc. Research and Management of Bitterbrush and Cliffrose in Western North America. Tiedemann, A.R., and K.L. Johnson (compilers). USDA Forest Serv. Gen. Tech. Rep. INT-152.

Oak Consumption by Cattle in Arizona

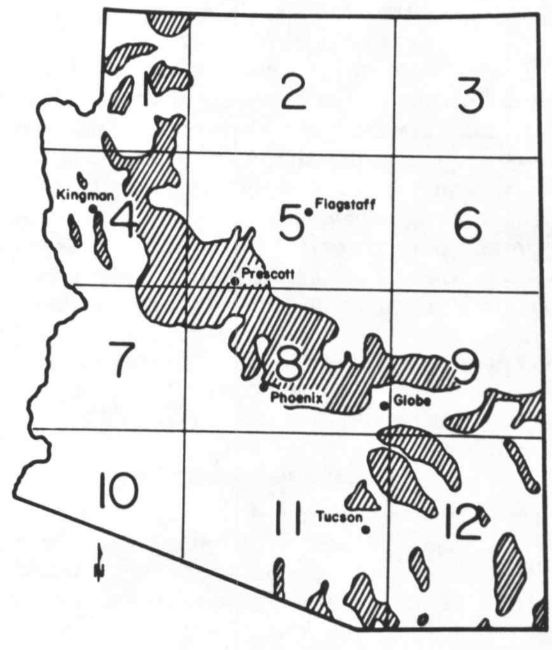
G.B. Ruyle, R.L. Grumbles, M.J. Murphy, and R.C. Cline

Cattle poisoning from consumption of oak leaves, buds, and acorns is widespread throughout the United States. The outbreak of oak bud poisonings that killed thousands of cattle in California during 1985 exemplifies the potential hazards that exist when livestock graze oak rangelands. Oak poisoning in cattle is generally a seasonal problem, occurring in the spring when new buds offer early green forage, and in the fall after acorns drop. The most likely toxic principles are tannic acids, or tannins. The level of toxicity is variable but poisoning problems can occur regardless of the plant part consumed (Kingsbury 1964, Panciera 1978).

Cattle can consume up to 50 percent oak buds and leaves in their diet without signs of poisoning but greater amounts lead to clinical toxicosis and death (Kingsbury 1964, Dollahite 1966). Tannin levels in oak may range from 2 to 6 percent (Dollahite et al. 1966). After ingestion, oak tannins are broken down into gallic acid and pyrogallol, chemicals toxic to cattle (Sandusky et al. 1977). Tannic acid toxicosis causes renal disease and subsequent kidney failure (Panciera 1978).

The initial clinical signs of oak poisoning in cattle include gauntness, listlessness, and constipation, followed by diarrhea, excessive thirst, and frequent urination (Kingsbury 1964). Rumen and renal function are reduced (Sandusky et al. 1977, Panciera 1978). Necropsy and histological findings are well-described (Sandusky et al. 1977, Panciera 1978), and should be easily recognized by a veterinarian. Histopathologic lesions are marked, and with the history of ingestion of oak leaves and necropsy lesions, a firm diagnosis can be made.

Oak consumption by cattle may also contribute to general unthriftiness of the cow herd long before the induction of



Shrub live oak distribution in Arizona. The twelve designated areas correspond to Table 1, and indicate general locations where cattle fecal samples containing oak were collected.

classical signs of toxicosis since tannins have negative effects on forage digestibility (McLeod 1974, Provenza and Malechek 1984). High levels of condensed tannins in livestock diets may depress protein and fiber digestion (McLeod 1974). It seems likely, therefore, that moderate levels of oak consumption by cattle, while not inducing the classical signs

Authors are range management specialist, Division of Range Management; Mohave County agriculture agent, Arizona Cooperative Extension Service; range technician, Division of Range Management, University of Arizona Tucson 85721; and manager, Wagon Bow Ranch, Kingman, Arizona 85401.

Arizona Agriculture Experiment Station article 4081.

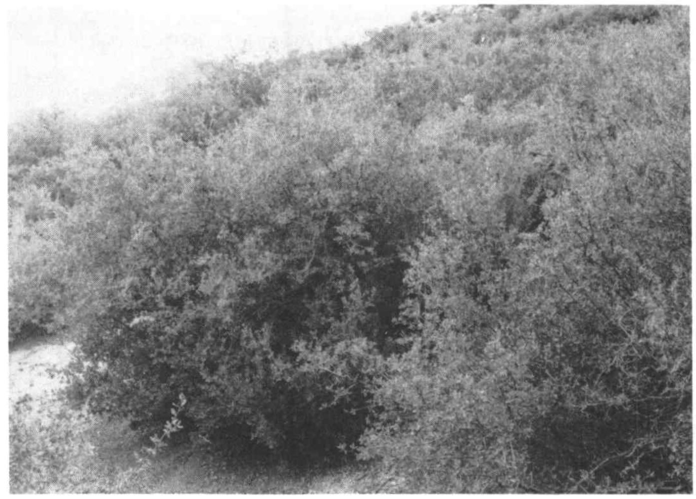
Table 1. Cases where more than 10 percent oak was found in cattle fecal samples analyzed from 1981 to 1985 by the Range Animal Diet Analysis Laboratory, University of Arizona.

Month	Area[1]	Number of cases	Oak species	$\overline{X}$ % in diet
January	1	3	*Quercus turbinella*	18
	4	5	*Quercus turbinella*	48
	5	1	*Quercus turbinella*	26
	9	1	*Quercus turbinella*	22
	11	1	*Quercus turbinella*	16
February	4	8	*Quercus turbinella*	45
	9	1	*Quercus turbinella*	12
	12	2	*Quercus turbinella*	34
March	4	2	*Quercus turbinella*	15
	5	1	*Quercus turbinella*	40
	12	2	*Quercus turbinella*	41
	12	1	*Quercus emoryi*	25
April	4	2	*Quercus turbinella*	38
	11	1	*Quercus turbinella*	49
	12	1	*Quercus turbinella*	12
May	1	3	*Quercus turbinella*	34
	4	1	*Quercus turbinella*	10
	9	1	*Quercus turbinella*	32
	12	1	*Quercus turbinella*	26
June	1	4	*Quercus turbinella*	13
	9	1	*Quercus turbinella*	15
	12	1	*Quercus emoryi*	13
July	4	1	*Quercus turbinella*	12
	9	1	*Quercus turbinella*	25
September	12	1	*Quercus turbinella*	12
October	9	1	*Quercus turbinella*	49
November	4	2	*Quercus turbinella*	17
	9	3	*Quercus turbinella*	44
	12	1	*Quercus turbinella*	52
	12	1	*Quercus hypoleucoides*	12
December	4	2	*Quercus turbinella*	44
	9	3	*Quercus turbinella*	42

[1]Corresponds to one of twelve areas designed on map illustrated in figure 1.

of poisoning, may well reduce overall herd productivity on rangelands where oak is a major component of the vegetation.

Twelve species of oak occur in Arizona (Kearny and Peebles 1960), of which, shrub live oak *(Quercus turbinella)* has the widest distribution. Oak has been implicated in numerous cattle poisonings in Arizona but is also suspected of causing reduced performance in range cow herds where it is thought to become a diet mainstay during certain seasons. To better document oak consumption by cattle in Arizona, we consulted files from the Range Animal Diet Analysis Laboratory at the University of Arizona. From over 6,000 diet samples on record, 438 contained some level of oak. From these, we compiled 60 cases where oak was found to average at least 10 percent of the diet based on two or more samples submitted from one location. Single animal samples and diets of less than 10 percent oak were omitted. Recognizing the shortcomings of the fecal analysis technique and that the entire state was not evenly represented in the records, we feel the data offer insights into conditions whereby oak may be consumed by cattle in deleterious quantities.



Shrub live oak in Mohave County, Ariz.

The major oak species consumed by cattle in Arizona is shrub live oak. Primary areas where oak is seen in cattle diets are in northwestern and southeastern Arizona where major belts of oak occur although oak is present throughout the state. Secondary species include emory *(Quercus emoryi)* and silverleaf oak *(Quercus hypoleucoides)*. These records show oak is an important diet constituent to cattle year around. Samples containing oak were collected in all months except August (Table 1). Cow diets in Arizona contained highest amounts of oak from December through April, ranging from 35 to nearly 40 percent. These levels, although not fatal, could seriously reduce cow performance. July, August, and September seem to be months when relatively little oak is consumed by cattle because the warm-season grasses provide the major forage on most Arizona ranges.

At low levels, oak is an important winter forage, but as tannin levels increase in cattle diets, roughage digestiblity may decrease. The subsequent reduction in energy and protein may cause problems not seen in seriously poisoned cows. Lower cow herd performance may manifest in decreased calf crops and calf weaning weights as has been witnessed on ranches in northwestern Arizona.

The obvious suggestion of using oak-free pastures is not helpful where entire ranches are covered with oak. However, oak-free pastures could be developed, ideally combined with the establishment of cool-season grasses. Although expensive, a good supplemental feeding program may be required during critical periods on ranches where oak poisoning is a problem. Calcium hydroxide, added to supplemental feeds at levels less than 10 percent, can prevent oak intoxication in cattle (Dollahite et al. 1966). The calcium hydroxide concentration must be low enough for the feed to be palatable but high enough to act as a tannin antidote. Calcium hydroxide is corrosive so care must be taken when handling the chemical.

Where oak is a problem on ranches, the critical periods when high oak consumption is most likely to reduce cattle performance must be identified. We recommend that ranchers provide cow fecal samples for analysis on a monthly or bi-monthly basis to estimate diet composition. Good grazing management, combined with a supplemental feeding program, may then be developed to deal with problems.

Literature Cited

Dollahite, J.W., G.T. Housholder, and B.J. Camp. 1966. Effect of calcium hydroxide on the toxicity of post oak *(Quercus stellata)* in calves. J. Amer. Vet. Medical Association 148:908-912.
Kearny, T.H., and R.H. Peebles. 1960. Arizona flora. Univ. of California Press, Berkeley, CA. p. 216-219.
Kingsbury, J.M. 1964. Poisonous plants of the United States and Canada. Prentice-Hall, Englewood Cliffs, NJ. p. 444-446.
McLeod, M.N. 1974. Plant tannins-their role in forage quality. Nutr. Abst. Rev. 44:803-815.
Panciera, R.J. 1978. Oak poisoning in cattle. *In:* Keeler, R.F., K.R. Van Kampen and L.F. James (eds.). Effects of poisonous plants on livestock. Academic Press, New York. p. 499-506.
Provenza, F.D., and J.C. Malecheck. 1984. Diet selection by domestic goats in relation to blackbrush twig chemistry. J. App. Ecol. 21:831-841.
Sandusky, G.E., C.J. Fosnaugh, J.B. Smith, and R. Mohan. 1977. Oak poisoning of cattle in Ohio. J. Am. Vet. Med. Assoc. 171:627-629.

Succession in Pinyon-Juniper Vegetation in New Mexico

Martin R. Schott and Rex D. Pieper

Pinyon-juniper is a major vegetation complex of the southwestern United States. One-seed juniper and pinyon are the major species of the complex in central New Mexico. Since settlement of the Southwest by Europeans, this vegetation type has increased in distribution and density of individual trees (West et al. 1975). A decline in forb and grass production accompanied these increases (Johnsen 1962). Because of the decline in forage production, land managers have attempted various types of pinyon-juniper control, often without an understanding of the ecology of the complex or an idea of how the vegetation will respond to the treatment. For example, cabling has been used extensively in the Sacramento Mountains of southcentral New Mexico as a form of pinyon-juniper control. Larger trees are pulled out of the ground, but many smaller trees and shrubs survive the cabling. The successional pattern following cabling and other types of disturbance is not understood for many areas in New Mexico.

Research concerned with secondary succession of pinyon-juniper communities where one-seed juniper and pinyon are the dominants has not been extensive. This article presents the result of several studies on pinyon-juniper succession in the Sacramento Mountains in south central New Mexico.

Factors Influencing Succession

Soil depth and the amount of rockiness in the upper soil horizons have a major influence on succession after a community is cabled. Succession after cabling was examined on two different soils: a Lithic Haplustoll rock outcrop complex and a Lithic Haplustoll. Each soil supports a different association, and the successional pattern on each soil is different.

Most studies reported several stages of succession: forb, grass, grass-shrub, shrub and climax. Succession on the Lithic Haplustoll rock outcropping complex does not have the grass or shrub stages. Rocky, broken soils tend to restrict the vegetative spread of blue grama and wavyleaf oak, and other species that spread vegetatively. Thus, the grass and shrub stages are not evident on this type of soil. On deeper soils these stages do develop during succession (Table 1).

Authors are former research assistant and professor of range science, Department of Animal and Range Sciences, Las Cruces, New Mexico 88003.
Journal Article No. 1156. New Mexico State University Agr. Exp. Sta.

Shrubs and trees are restricted to soil patches between the rock outcrops. Because of the patchy soil, little interspecific competition for moisture occurs between the shrubs and trees, except for the patches of soil where wavyleaf oak and junipers occur. Because of the separation, wavyleaf oak is a member of the climax community on these soils.

Pinyon was the only tree that increased in coverage in the 28 years after cabling. Compared to junipers, it is a fast-growing species that produces seeds at younger ages. Both one-seed juniper and alligator juniper grow and mature slowly. Germination trials indicate young one-seed junipers produce seeds of low viability. Apparently, most juniper establishment after cabling is from seeds already on the site at the time of cabling, or seeds brought in by an animal vector. One-seed juniper seeds can remain viable for 20 years. Trees that become established require a minimum of 10-30 years of growth to produce seeds. Except for seeds that did not germinate and those brought in by animals, a seed source is not available until the established trees have matured. Lack of a continuous seed source and the slow growth of junipers accounts for the lack of increase in canopy 28 years after cabling.

Successional Patterns

The Lithic Haplustoll supported a pinyon-juniper/blue grama habitat type. Secondary succession of this habitat type after cabling is similar to the general successional models of Arnold et al. (1964) and Barney and Frischknecht (1974). Initially, the community is dominated by perennial grasses and forbs. An annual community may develop if perennial grasses were not common to the area before cabling. Shrubs such as wavyleaf oak and skunkbush gradually begin to dominate the grass-forb community, after which pinyons and junipers become established under the shrub canopy. Trees finally dominant the area. Rate of succession after cabling is faster than that proposed by the general models, but these were based on succession after catastrophic fire where more plants are destroyed.

Rate of succession after cabling depends on community