Spy Mesa Yields Better Understanding of Pinyon-Juniper in Range Ecosystem

ALBERT P. THATCHER AND VIRGIL L. HART

Highlight: A 2-year study on the Spy Mesa relict of the Arizona Strip provides information concerning the natural occurrence of pinyon-juniper in range ecosystems of this area. The 40-acre relict is unique because there is a wide variety of soils and natural fires have occurred over the past 50 years. The plants have been grazed by rodents and mule deer and yet they have been inaccessible to livestock. This study reveals that, following natural fires, grass became significant in the plant community only on soils that had sandy surface textures. Pinyon-juniper was the dominant species in the absence of fire, regardless of the kind of soil. Those soils having a vesicular, massive, or platy surface layer did not produce significant quantities of grass at any stage of plant succession.

Rangeland relicts have long been used to determine the potential productivity of ranges and the adaptation of plant species to soil and climate. Relict areas have also served for the study of variations in plant communities as influenced by weather, fire, fauna, and other natural factors operating within the ecosystem. Such areas often are the only real benchmarks from which the natural plant communities can be reconstructed. But, in using data from these areas, all factors of the environment should be considered. Small differences in soil, the presence or absence of fire, and the direction and degree of slope can cause dramatic differences in species composition and production.

Within the large area often referred to as the pinyon (*Pinus edulis*) - juniper (*Juniperus spp.*) zone, there is much diversity in the composition of plant communities. Some areas are almost completely dominated by pinyon and/or juniper while in other areas neither species is found even though the plant communities have been completely altered due to abusive grazing and absence of fire. Some of the major questions that confront the student or the manager of these kinds of

rangelands are: (1) How much pinyon or juniper is natural for the site, (2) what kind of management techniques are necessary to control the amount of pinyon-juniper, and (3) what results can be expected when these small trees are removed from the plant communities?

Reporting on the effect of fire in pinyon-juniper zones, Dwyer and Pieper (1967) found that wildfire resulted in a significant reduction of the trees and that grass recovered from the initial damage by the second year. Aro (1971), in his evaluation of pinyon-juniper conversion to grassland, states that controlled burning should be the primary conversion technique where vegetation is dense enough to carry an effective fire. Arnold et al. (1964) recognized that natural fires played a role in controlling the invading juniper and that controlled burns, either as broadcast burns or individual tree burns, were a valuable tool to manage these kinds of lands.

The response to pinyon-juniper control has been varied. McCulloch (1966) reports that the yield of cliffrose (*Cowania mexicana*) increased significantly following bulldozing of juniper from a site on the north Kaibab Plateau in northern Arizona. Judd (1966), in a study of seeding establishment and longevity of stand, shows that good results were obtained following removal of juniper from a site identified as Buckhead Mesa. In a 1969 study on areas in northern Arizona that had been cleared of pinyon-juniper, O'Rourke and Ogden found grass and forbs increased very little where the calcium carbonate (13%) was found in the surface foot of soil. Crown cover of pinyon-juniper was also relatively low in those areas associated with a poor increase in perennial grass production following brush control.

The influence of soil characteristics on the amount and kind of native vegetation has been recognized by many people who have studied pristine plant communities. Passey and Hugie (1962) demonstrated that detailed soil information can be related to the kinds and amounts of vegetation found in natural plant communities.

Mason (1967), in a relict area study at No Man's Land Mesa in Utah, found two distinct plant communities directly related to distinct differences in soil. Jameson (1962), in a study of

Authors are state range conservationist, U.S. Department of Agriculture, Soil Conservation Service, Phoenix, Arizona, and natural resource specialist, U.S. Department of the Interior, Bureau of Land Management, Phoenix, Ariz.

Manuscript received December 8, 1973.

Table 1. Vegetation composition (%) and yields (lb/acre) of vegetation on six different soils identified on Spy Mesa in northern Arizona.

Composition	Soil number						
	1	2	3A	3B	4	5	6
<i>Aristida fendleriana</i>	TR ¹	2	1	TR	TR	—	—
<i>Bouteloua gracilis</i>	—	—	—	—	TR	—	—
<i>Bouteloua curtipendula</i>	—	—	—	—	TR	—	—
<i>Chrysothamnus viscidiflorus</i>	6	—	—	—	—	13	1
<i>Cowania mexicana</i>	3	5	1	—	5	—	—
<i>Ephedra viridis</i>	7	—	11	—	1	9	8
<i>Euphorbia setiloba</i>	TR	—	—	—	—	—	—
<i>Gutierrezia lucida</i>	3	19	1	TR	—	—	8
<i>Hilaria jamesii</i>	TR	—	5	4	TR	60	2
<i>Juniperus osteosperma</i>	67	67	16	3	83	8	25
<i>Opuntia polyacantha</i>	TR	—	—	1	1	1	1
<i>Pinus edulis</i>	8	4	—	—	7	—	—
<i>Rhus trilobata</i>	TR	1	—	—	TR	—	—
<i>Shepherdia rotundifolia</i>	2	—	—	—	—	—	—
<i>Stipa speciosa</i>	TR	2	63	91	TR	10	56
<i>Tridens muticus</i>	TR	TR	—	—	—	—	TR
<i>Tridens pulchellus</i>	—	—	—	—	—	—	—
Total annual yield	498	405	971	1308	442	1120	993

¹ TR = less than 0.5% composition.

the Fishtail Mesa relict in northern Arizona, shows a strong correlation of soil and natural plant communities in the pinyon-juniper type. Klemmedson (1970) recognized the need for detailed soil information so that correct decisions can be made regarding treatment of the range resource.

The magnitude of pinyon-juniper invasion into grassland has been recognized by several authors including Arnold et al. (1964), who reported that both trees and shrubs increased in areas both protected and grazed between 1940-1953. The understory plants decreased as the amount of pinyon-juniper overstory increased. Pinyon-juniper control methods, both by mechanical means and by fire, were evaluated. In general, the results have been an increase in grasses, forbs, and shrubs. Jameson and Reid (1965) also indicate that the pinyon-juniper invasion in northern Arizona is widespread and that this invasion will continue even if areas are protected from grazing. They further report that understory vegetation is suppressed as this invasion grows.

Study Area and Procedure

The Spy Mesa relict is 40 acres in size and is located 15 miles south of Colorado City in the part of northern Arizona known as the "Arizona Strip." The elevation at the top of the mesa is approximately 5,000 feet. Using the records of the nearby weather station at Fredonia, Arizona, it was estimated this area receives an average of 13 inches of precipitation annually, about 50% of which is received during the period of July through October. The average annual temperature is about 52° F. Extreme temperatures range from a high of 105° down to -15° F.

Spy Mesa is a true relict in the sense that all apparent factors of the natural environment have been allowed to function without the influence of modern man and his domestic livestock. Activities of wildlife observed here were those of deer, porcupine, rabbits, ground squirrels, and coyotes. Although it was impossible to determine frequency of wildfires, there was abundant evidence of relatively recent fires (Fig. 1) having occurred. Also in evidence were situations where individual trees had been killed by lightning fires or, in the case of the pinyon, being killed by activities of porcupine.

The area lies well within the pinyon-juniper zone of the intermountain area. The floristic composition is quite rich,

Fig. 1. Plant community growing on soil 3. This burned recently as evidenced by burned stump near center of picture. Vegetative production shown in column 3B in Table 1.

with 27 species identified. About 15 species (Table 1) contribute significantly to the vegetative production of one or more of the soils.

Soil differences, a wide variability in kinds of vegetation, the occurrence of natural fires, and the influence of various kinds of wildlife make the Spy Mesa relict ideal as a study area.

The study of the relict was initiated by an intensive soil investigation. Detailed soil profile descriptions were written noting all characteristics at each identifiable horizon as shown in Figure 2. Soil profiles for each of the study areas were numbered 1 through 6. No attempt was made to identify these soils as to series, type, or phase.

Vegetative transects were established within each of the six

Fig. 2. Soil profile characteristics of the six soils studied.

Fig. 3. Typical view of vegetation found growing on soil 1. Large areas are nearly barren and filled with pinyon and juniper roots.

Fig. 4. Vegetation growing on soil 2. Vegetation occupying this site on death of juniper (lower left) consisted of snakeweed (*Gutierrezia lucida*) and rabbitbrush (*Chrysothamnus viscidiflorus*).

Fig. 5. Plant community found growing on soil 4. Snakeweed (*Gutierrezia lucida*) is occupying area around the dead skunkbush (*Rhus trilobata*).

Fig. 6. Plant community which has developed on soil 6. Desert needlegrass (*Stipa speciosa*) is abundant in area once occupied by the dead juniper.

soil areas. Care was taken to avoid sampling small inclusions of other soils that might lie within the soil boundary. The vegetation was measured using the double sampling procedure with production expressed as pounds of air dry annual herbage produced per acre. Plots of 9.6 ft² were used to sample grasses, forbs, and small shrubs. Nested 1/10-acre plots were used to sample the larger shrubs and trees. Production data were obtained from a minimum of ten sample plots on each transect. Total pounds/acre and pounds/acre of each species were recorded for each soil area and summarized in Table 1.

Results and Discussion

Soil areas numbered 1 (Fig. 3), 2 (Fig. 4), and 4 (Fig. 5) primarily produced pinyon pine, juniper (*J. osteosperma*), and

shrubs of various types as shown in Table 1. Grass production was slight to nonexistent. This was true even when the trees or shrubs were lost in the plant community as the result of fire, senility, and destruction by porcupine or disease. On these soils, the ecosystem changes are from trees to shrubs and back to trees again (Fig. 4 and Fig. 5). Grass did not appear to any significant extent at any of the stages of plant succession. The soil factors that cause this phenomenon are not exactly known. The one identifiable soil characteristic common to these three soils is the vesicular, massive, or platy surface layer. Soil scientists have associated this with poor water infiltration rates. It seems logical that soils with high water runoff characteristics would have less available moisture and thus be

Fig. 7. Plant association growing on soil 3. This area has not recently burned (column 3A of Table 1). Grasses are in the understory but are reduced in production because of pinyon and juniper competition.

under greater moisture stress. This soil factor could eliminate from the plant community those plants that are not able to compete for limited moisture under drought conditions.

Soil areas 3 (Fig. 1), 5 and 6 (Fig. 6) produced in all cases significant amounts of grass. The amount of grass (on these soils) seemed to be inversely related to the amount of pinyon and juniper, which in turn was inversely related to the frequency of fire or other means by which the trees died. Those sites where fire had recently functioned in the plant community (column 3B in Table 1) produced 1,271 lb/acre of desert needlegrass (*Stipa speciosa*). Where fire had not played a recent role in the development of the plant community (Fig. 7) and (Column 3A in Table 1), the amount of desert needlegrass was 612 lb/acre. Here again it is not fully understood why these soils produce significant quantities of grass. The one thing that each of these three soils has in common is the granular sandy loam surface soil layer on which common is the granular sandy loam surface soil layer on which moisture infiltration rates into the soil profile would be ideal. As there were apparently no adverse soil conditions such as high pH, salinity, and slowly permeable subsoil horizons, the authors believe that this soil surface condition plays the primary role in determining the significant production of grass in these three plant associations.

High lime concentrations in the soil profile were apparently not a characteristic which limited the amount of grass production. One soil with little or no lime in the soil profile produced little or no grass, while two of the soils which produced grass had at least moderate concentrations of lime somewhere in the soil profile.

Conclusions

What appeared at first to be a disarray of plant communities, i.e., nearly pure stands of grass in parts of the relict and plant communities made up of pinyon, juniper, and shrubs with very little grass in other areas, became understandable only after detailed soil investigations were completed. These two basic plant communities were even more clearly defined when the influence of fire was noted.

Soils with vesicular, massive, or platy surface layers did not produce significant quantities of grass in any stage of plant succession. The principal plants produced on these soils were primarily confined to pinyon, juniper, and shrubs.

Those soils with granular sandy loam surface layers, even when very shallow, produced relatively large quantities of grass under natural ecological conditions.

The data supplied here contributes to a better understanding of soil conditions that allow natural establishment of grass following juniper controls for these kinds of soils in this type of climate.

Literature Cited

- Arnold, Joseph S., Donald A. Jameson, and Elbert H. Reid. 1964. The pinyon-juniper type of Arizona: Effects of grazing, fire and tree control. Forest Service, U.S. Dep. Agr. Prod. Res. Rep. 84. 28 p.
- Aro, Richard S. 1971. Evaluation of pinyon-juniper conversion to grassland. J. Range Manage. 24:188-197.
- Dwyer, D. D., and R. D. Pieper. 1967. Fire effects on blue grama-pinyon-juniper rangeland in New Mexico. J. Range Manage. 20:359-362.
- Jameson, Donald A., John A. Williams, and Eugene W. Wilton. 1962. Vegetation and soils of Fishtail Mesa, Arizona. Ecology 43:403-410.
- Jameson, D. A., and Elbert H. Reid. 1965. The pinyon-juniper type in Arizona. J. Range Manage. 18:152-153.
- Judd, Ira B. 1966. Range seeding success on the Tonto National Forest, Arizona. J. Range Manage. 19:296-301.
- Klemmedson, James O. 1970. Needs for soil information in management of range resources. J. Range Manage. 23:139-143.
- Mason, L. R., Horace M. Andrews, James A. Corley, and E. Dwain Haacke. 1967. Vegetation and soils of No Man's Land Mesa relict area, Utah. J. Range Manage. 20:45-49.
- McCulloch, Clay Y. 1966. Cliffrose browse field on bulldozed pinyon-juniper areas in northern Arizona. J. Range Manage. 19:373-374.
- O'Rourke, J. T., and P. R. Ogden. 1969. Vegetative response following juniper control in Arizona. J. Range Manage. 22:416-418.
- Passey, H. B., and V. I. Hugie. 1962. Application of soil-climate relations to soil survey interpretations for rangelands. J. Range Manage. 15:162-166.

Indexes to JRM:

Complete author, title, and subject matter indexes are available for the first 20 volumes of the *Journal of Range Management*.

Index No. 1 for Vols. 1-10 (1948-57) @ \$1.00

Index No. 2 for Vols. 11-20 (1958-67) @ \$1.50

Set of both indexes @ \$2.00

Order from Society for Range Management, 2120 So. Birch Street, Denver, Colorado 80222.

JRM on Microfilm:

University Microfilms (a Xerox company) has recently completed microfilming all back volumes of the *Journal of Range Management*. Volumes 1-24 (1948 through 1971) are now available on 35 mm film at a price of \$68.40; Volume 25 (1972) is priced at \$4.30.

For libraries, institutions, or individuals who want a complete set of JRM—without worrying about lost issues or storage space—35 mm microfilm is the way to go.

Orders and inquiries should be directed to University Microfilms, 300 No. Zeeb Road, Ann Arbor, Michigan 48106.