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## Mesquite Removal and Mulching Treatment Impacts on Herbage Production and Selected Soil Chemical Properties

**Abstract:** Determining the effects of mesquite (*Prosopis velutina*) overstory removal, post-treatment control of sprouting, and mulching treatments on herbage production (standing biomass) and selected soil chemical properties on the Santa Rita Experimental Range were the objectives of this study. Mesquite control consisted of complete overstory removals with and without the control of the resulting regrowth of stump sprouts. The mulching treatments were applications of mesquite wood chips, commercial compost, and lopped-and-scattered mesquite branchwood. Herbage production was estimated in the spring and early fall to determine total annual production and the production of early growers and late growers. Mesquite removal resulted in increases in herbage production. Mesquite removal had no effect on the soil chemical properties considered. The mulching treatments did not have an affect on herbage production, although a few of the soil chemical properties were affected by some of the mulching treatments.

**Keywords:** mesquite removal, mulching treatments, herbage production, soil chemical properties

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### Introduction

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Increases in woody plants such as mesquite have been a long-time concern of rangeland managers and livestock producers in the Southwestern United States because this encroachment has often reduced herbage production and, therefore, livestock production (Heitschmidt and Dowhower 1991; Herbel and others 1983; Laxson and others 1997; Martin and Morton 1993). The encroachment of mesquite onto otherwise productive rangelands has been attributed to earlier overgrazing by livestock, reduced frequency of large-scale wildfire, changes in chemical, biological, and physical properties of the soils, and changes in climatic patterns (Herbel 1979; Martin 1975; McPherson 1997). One reason for establishment of the Santa Rita Experimental Range was to study methods of restoring depleted rangeland conditions brought about by earlier heavy livestock grazing. Among these strategies was improving rangeland conditions by controlling the invasion of mesquite.

The intent of this study was to determine the changes in herbage production (standing biomass) and selected soil chemical properties that might affect herbage production in response to mesquite removals with and without the control of the resulting regrowth of stump sprouts, the addition of mulching, or combinations thereof. Information of this kind could be incorporated into management practices to enhance the productivity of semidesert grass-shrub rangelands in the future. Preliminary results of the effects of mesquite removal and mulching treatments on herbage production were reported by Pease and others (2000).

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## Description of Study

The study area was located within the Desert Grassland Enclosure on the Santa Rita Experimental Range, an area that had not been grazed by livestock for 70 years or more. Descriptions of the climate, soils and other physiographical features, and vegetation of the Experimental Range are presented elsewhere in these proceedings. Within the study area, mesquite dominates the woody overstory, and Lehmann lovegrass (*Eragrostis lehmanniana*), an introduced species that was initially planted on the Experimental Range in 1937 (Cable 1971; Cox and Roundy 1986; Ruyle and Cox 1985), dominates the herbaceous understory vegetation. Native herbage species include *Eriogonum wrightii*, *Solanum elaeagnifolium*, and *Gnaphalium purpureum*, while common annual species are *Chenopodium album*, *Eschscholtzia mexicana*, and *Descurainia pinnata*. There are two growing seasons for the herbaceous plants. One season is early spring when temperatures and antecedent soil moisture are favorable, while the other is late summer or early autumn in response to summer rains.

## Study Design and Treatments

The study design consisted of 60 5- by 5-m plots containing a mesquite tree or shrub with a minimum 1-m buffer between the plots. The plots were blocked on the basis of information from a pretreatment mesquite overstory inventory that indicated the structure and size of the mesquite tree or shrub in the plot. Treatments were then randomly assigned to the plots. The treatments, applied in early July 1995, consisted of three overstory treatments and four mulching treatments within each of the overstory treatments. Each combination of overstory treatment and mulching treatment was replicated five times. The three overstory treatments were complete removal of the mesquite overstory with and without the control of the resulting regrowth of stump sprouts by hand cutting in July 1997 and an untreated control. The mulching treatments included applications of a chip mulch, a commercial compost, lopped-and-scattered mesquite branchwood, and a control. The chip mulch, obtained from chipping the cut mesquite branchwood, was uniformly distributed on the plots to a depth of 15 to 25 mm. The commercial compost was fir based with 0.5 percent nitrogen, 0.1 percent iron, and 0.2 percent sulfur. Approximately 0.25 m<sup>3</sup> of the compost was applied to the plots. The lopped-and-scattered mesquite branchwood was spread to completely cover the plot.

## Data Collection and Analysis

Herbage production was estimated biannually (spring and fall) in May and October from 1995 through 1999 by the weight-estimate method of sampling described by Pechanec and Pickford (1937) on 0.89-m<sup>2</sup> plots. The herbage samples were dried, separated by plant species, weighted, and extrapolated to kilograms per hectare. Selected soil chemical properties were sampled annually from May 1995 through 1998. A composite of 12 subsamples was obtained from the top 5 cm of the soil on each plot. The soil samples were collected along a diagonal transect situated across the plots

with 0.3 m between the subsamples. The samples were analyzed for total nitrogen, nitrate, total organic carbon, total phosphorus, plant available phosphorus (Olsen phosphorus), and pH at the Soil, Water, Plant Analysis Laboratory of the University of Arizona, Tucson. These chemical soil properties were selected to provide the basis for a comparative analysis of a counterpart investigation in northern Israel on controlling shrub cover to increase grass productivity (Perevolotsky and others 1998).

Precipitation (mostly rainfall) was measured by a standard weighing gage located near the desert grassland enclosure. It was assumed that precipitation affecting early spring (early) growers fell from November through May, while the precipitation that fell from June through October impacted the late summer-early autumn (late) growers.

Analyses of variance were conducted to determine whether significant differences occurred in herbage production and the selected soil chemical properties among the overstory removal and/or mulching treatments. Herbage production of early growers and late growers was analyzed separately. Tukey-Kramer HSD was used to determine which treatment(s) had significantly different effects on herbage production. All statistical analyses were evaluated at a 0.10 level of significance.

## Results and Discussion

### Herbage Production

Total herbage production averaged 1,896 ± 115 kg per ha per year (mean ± standard error) from 1995 to 1999 on the plots receiving the two mesquite overstory treatments, and 1,554 ± 94 kg per ha per year on the control plots. The post-treatment control of resprouting did not significantly affect total herbage production. Reduced competition between mesquite and herbaceous plants for soil moisture likely contributed to the increased total herbage production on the treated plots. However, the observed increase was less than that reported in earlier studies of herbage responses to the removal of mesquite overstories (Herbel and others 1983; Heitschmidt and Dowhower 1991; Laxson and others 1997; Martin and Morton 1993).

The mesquite overstory removal treatments had no significant effect on the production of early growers, a finding that was largely attributed to the (48 percent) below-average precipitation in the period of this growing season. However, the production of late growers on the plots with mesquite removal and no post-treatment control of sprouting was greater (1,278 ± 89 kg per ha per year) than either the plots with overstory treatment and post-treatment control of sprouting or the control; the production of late growers was statistically the same (1,042 ± 69 kg per ha per year) on these latter plots. The shade provided by the resprouting mesquite might have been a causal factor for this observed increase (Shreve 1931; Tiedemann 1970).

The mulching treatments had no impact on total annual herbage production or the production of early or late growers. This result was attributed to the below average amounts of annual precipitation in the 5-year study period and, to some extent, the possibility that inadequate levels of mulch were applied to affect soil moisture availability. Biedenbender

and Roundy (1996) suggested that mulching treatments might not sufficiently affect soil moisture availability and, as a consequence, the establishment and growth of herbage plants in periods of low and infrequent rainfall.

Interaction effects between the overstory and mulching treatments on total herbage production and the production of early or late growers were all insignificant.

## Soil Chemical Properties

The overstory removal treatments had no effect on the soil chemical properties evaluated. A decline in nutrient availability 13 years following the removal of mesquite on the Experimental Range was observed by Klemmedson and Tiedemann (1986). However, the duration of this current study might not have been of sufficient length to adequately reflect the impacts of mesquite removal on the soil chemical properties evaluated.

The mulching treatments had no significant effects on nitrate, total organic carbon, or total phosphorus of the soil, but these treatments did affect total nitrogen, plant available phosphorus, and pH. Total nitrogen was higher on the lopped-and-scattered plots than the control plots. The plots receiving the compost and chipped mulch had a higher pH than the control plots. There was a negative correlation between pH and plant available phosphorus on the plots with the compost and chipped mulches. These changes in soil chemical properties were small in their magnitude, however, and their impacts on herbaceous plant growth is unknown.

## Conclusions

This study was conducted in a 5-year period of prolonged drought. The departures of 30 percent or more in average annual precipitation in the study period might have masked the treatment effects on annual herbage production and the selected soil chemical properties. Further investigation of the effects of mesquite removal and mulching treatments on herbage production and soil chemical properties is necessary to more completely evaluate the affects observed in this study. Nevertheless, information such as that presented in this paper can be useful to managers in attempting to enhance the productivity and stewardship of semidesert grass-shrub rangelands.

## References

- Biedenbender, S. H.; Roundy, B. A. 1996. Establishment of native semidesert grasses into existing stands of *Eragrostis lehmanniana* in southern Arizona. *Restoration Ecology*. 2: 155–162.
- Cable, D. R. 1971. Lehmann lovegrass on the Santa Rita Experimental Range. *Journal of Range Management*. 24: 17–21.
- Cox, J. R.; Roundy, G. B. 1986. Influence of climatic and edaphic factors on the distribution of *Eragrostis lehmanniana* in Arizona, U.S.A. *Journal of the Grassland Society of South Africa*. 3: 25–29.
- Heitschmidt, R. K.; Dowhower, S. L. 1991. Herbage response following control of honey mesquite within single tree lysimeters. *Journal of Range Management*. 44: 144–149.
- Herbel, C. H. 1979. Utilization of grass- and shrublands of the south-western United States. In: Walker, B. H., ed. *Management of semi-arid ecosystems*. Amsterdam, The Netherlands: Elsevier Scientific Publishing Company: 161–203.
- Herbel, C. H.; Gould, W. L.; Leifeste, W. F.; Gibbens, R. P. 1983. Herbicide treatment and vegetation response to treatments of mesquites in southern New Mexico. *Journal of Range Management*. 36: 149–151.
- Klemmedson, J. O.; Tiedemann, A. R. 1986. Long-term effects of mesquite removal on soil characteristics. II. Nutrient availability. *Soil Science Society of America Journal*. 50: 476–480.
- Laxson, J. D.; Schacht, W. H.; Owens, M. K. 1997. Above-ground biomass yields at different densities of honey mesquite. *Journal of Range Management*. 50: 550–554.
- Martin, S. C. 1975. Ecology and management of Southwestern semidesert grass-shrub ranges: the status of our knowledge. Res. Pap. RM-156. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.
- Martin, S. C.; Morton, H. L. 1993. Mesquite control increases grass density and reduces soil loss in southern Arizona. *Journal of Range Management*. 46: 170–175.
- McPherson, G. R. 1997. *Ecology and management of North American savannas*. Tucson: University of Arizona Press. 208 p.
- Pease, S.; Ffolliott, P. F.; DeBano, L. F.; Gottfried, G. J. 2000. Effects of mesquite control and mulching treatments on herbage production on semiarid shrub-grasslands. In: Ffolliott, P. F.; Baker, M. B., Jr.; Edminster, C. B.; Dillon, M. C.; Mora, K. L., tech. coords. *Land stewardship in the 21<sup>st</sup> century: the contributions of watershed management*. Proc. RMRS-P-13. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 265–267.
- Pechanec, J. F.; Pickford, G. D. 1937. A weight estimate method for determination of range or pasture production. *Journal of the American Society of Agronomy*. 29: 894–904.
- Perevolotsky, A.; Schwartz, R.; Hadar, L.; Yonatan, R. 1998. Controlling shrub cover and increasing grass productivity in semi-arid environments. Bet Dagan, Israel: Agricultural Research Organization. 12 p.
- Ruyle, G. B.; Cox, J. 1985. Lehmann lovegrass—a naturalized citizen. *Arizona Farmer Stockman*. 51(4): 26.
- Shreve, F. 1931. Physical conditions in sun and shade. *Ecology*. 12: 96–105.
- Tiedemann, A. R. 1970. Effect of mesquite (*Prosopis juliflora*) trees on herbaceous vegetation and soils in the desert grassland. Tucson: University of Arizona. 159 p. Dissertation.