

Piñon-Juniper Management Research at Corona Range and Livestock Research Center in Central New Mexico

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Abstract—New Mexico State University's Corona Range and Livestock Research Center (CRLRC) is located in a piñon-juniper (PJ)/grassland ecotone in the southern Basin and Range Province in south central New Mexico. A number of research projects conducted at this facility revolve around soil, plant, livestock, and wildlife responses to PJ woodland management. The objective of this paper is to provide an overview of on-going research at CRLRC dealing with sustainable management of PJ ecosystems. This paper is divided into 2 sections; the first deals with mature PJ woodland management research, while the second covers current juniper reinvasion suppression studies. We have compiled contributions from a team of faculty and graduate students that conducts research at CRLRC. Names of investigators are listed after each project title.

Introduction

Corona Range and Livestock Research Center (CRLRC) is a 11,330-ha research facility operated by New Mexico State University located approximately 22.5 km east of the village of Corona, New Mexico in a piñon-juniper (PJ) /grassland ecotone. Over half of its area has been classified as actual or potential PJ woodland and much of the research conducted at CRLRC, therefore, revolves around soil, plant, livestock, and wildlife responses to PJ woodland management.

Average elevation at CRLRC (Lat 34° 15' 36" N, Long 105° 24' 36" W) is 1,900 m and mean annual precipitation across the facility is 400 mm. Most rainfall occurs during the months of July and August as short duration convectional thunderstorms. Over 20 different soil associations are present on CRLRC and about 301 plant species belonging to 60 families have been identified on the facility (USDA-SCS 1970, 1983; Forbes and Allred 2001). Approximately half the area of CRLRC is covered by oneseed juniper (*Juniperus monosperma*) - piñon pine (*Pinus edulis*) woodlands; the remaining area has shortgrass plant communities dominated by blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*) and New Mexico feathergrass (*Stipa neomexicana*). Primary productivity of grassland sites ranges from less than 200 Kg/ha/yr during drought years (207 mm annual PPT) to over 1,000 Kg/ha/yr in moist years (455 mm annual PPT) (McDaniel 2002).

Since NMSU began managing this facility in 1989, grazing has been moderate across the ranch. CRLRC is currently grazed by cattle and sheep at a rate of approximately 28 ha/AU/yr. A base population of about 300 female mule deer (*Odocoileus hemionus*) and 100 pronghorn antelope (*Antilocapra americana*) are present on the facility.

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The objective of this paper is to provide an overview of on-going research projects at CRLRC that deal with sustainable management of PJ ecosystems. This paper is divided into two sections; the first deals with mature PJ woodland management research, while the second covers juniper reinvasion suppression experiments. We compiled contributions from a team of faculty and graduate students that conducts research at CRLRC. Names of investigators are listed after each project title.

Influence of Piñon-Juniper Clearing on Soil Water Dynamics, Livestock Distribution, and Mule Deer Population Numbers

Approximately 28% of the woodland area at CRLRC was mechanically cleared in the 1980s; an additional 40% was thinned with aerially applied herbicides in the mid 1990s (McDaniel 2002). Chemically cleared pastures have received either winter or summer season-long or rotational grazing since treatments were applied. Understory response to chemical control of adult trees ranged from increases of 0.3 to 3 times the existing herbaceous basal cover under mature woodlands. PJ removal has created a mosaic of treated and intact woodlands across much of the ranch (fig. 1). What follows is a brief description of a number of current research projects that focus on the implications of PJ removal on soil water dynamics, cattle grazing distribution, and mule deer dynamics.



Figure 1—PJ-dominated areas at CRLRC. (Top) Encroaching saplings on areas that were mechanically cleared in the 1980s. (Bottom) Standing dead tree snags in areas that were chemically thinned with aerial application of tebuthion clay pellets in the 1990s (Photos: J. Boren, 2005.)

Soil moisture dynamics under oneseed juniper trees in relation to chemical tree control and understory defoliation

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Effects of clearing oneseed juniper woodlands on forage yield for cattle and big game has been studied extensively (Pieper 1995). However, less is known about the influence of such treatments on soil water dynamics. It is often assumed that juniper clearing is associated with an increase in groundwater recharge, yet the fate of moisture otherwise used by juniper trees could vary considerably depending on overall rainfall, soil texture, depth to caliche layer, and herbaceous understory cover among other factors (Huxman and others 2005).

A 2-year study is being conducted to monitor soil water dynamics under chemically treated (dead) and live oneseed juniper trees. Interactions among vegetation, soils, and understory defoliation regime are being characterized. CS616 soil moisture probes located at 3 depths beneath the tree canopy drip lines were installed in 24 plots under dead and living trees inside cattle-grazing exclosures (fig. 2). Placement of soil moisture probes was determined in a preliminary study that showed no significant variation in superficial soil moisture content at different



Figure 2—Installing soil moisture probes in plots under live juniper trees and dead snags in a cattle grazing exclosure at CRLRC. (Photos: M. and N. Morris, 2005.)

locations under tree canopies. Each probe is connected to a data logger that also records rainfall data from a gauge placed at a central location in every enclosure. Preliminary data gathered in 2005 suggest that the rate of superficial soil moisture depletion under dead trees was higher than under their live counterparts. Basal cover of herbaceous understory beneath dead juniper snags was up to 3 times higher than under live trees and may have been responsible for the apparent differences observed. Soils under live trees, however, tended to exhibit lower volumetric soil moisture content. Heavy clipping of herbaceous understory was apparently associated with higher levels of superficial soil moisture content. This study will allow initial insights into the effects of tree removal on soil moisture dynamics and will expand current understanding about understory-overstory interactions in PJ ecosystems.

Cattle Feeding Site Selection in Pastures with a Mosaic of Intact and Cleared PJ Woodlands

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Development of sustainable management strategies for PJ rangelands requires quantifying the potential trade-offs involved in traditional tree-clearing practices. The well-known benefits of increased grass production after tree removal could at some point be offset by decreased shelter for cattle or cover for mule deer. Since calving is possibly the single most important event affecting the income of a cow-calf operation, a study was set up to determine the importance of PJ woodlands as shelter for pregnant and nursing cattle.

During the first 2 years of this study (2004 and 2005), 8 pregnant and 8 open cross-bred and Angus cows were tracked with GPS collars (Lotek Engineering Inc.) set to record animal locations, neck movement and temperature at 5 minute intervals. Eight animals (4 pregnant and 4 open) from a herd of approximately 80 young mother cows were collared a week before expected calving date each year. Different cows were collared in each year. The herd was first placed in a 138-ha pasture (Horse pasture) for approximately 20 days. After that, they were moved into a 219-ha pasture (Mesa pasture) where they remained until the end of this study. Piñon-juniper had been mechanically cleared from approximately half the area of both pastures during the 1980s.

So far, results show that cattle mostly avoided PJ woodlands except during periods when forage was scarce (less than 280 kg/ha) and wind chill-corrected air temperatures fell below 30 °F for 4 consecutive days. Under such conditions, cattle spent up to 90% of their day in wooded areas (fig. 3). Overall, cattle preferred open to dense PJ and tended to spend more time in PJ during the morning than afternoon hours. Pregnant cows spent considerably more time in PJ than open cows on calving day and on the days immediately before and after calving. Otherwise, both open and nursing cows tended to show similar preference for wooded areas. Compared to open cows, nursing mothers tended to spend less time at water, explore smaller areas on any given day, and spend more time in dense PJ during the afternoons.

PJ woodlands appear to play an important role in providing shelter for cattle during calving in years when forage is scarce. We are planning simple modeling exercises to determine the implications of observed PJ preference patterns on energy status of lactating cows. Because mule deer and cattle have similar standard operative temperatures (animal's thermal environment) under windy conditions, heavy use of PJ by cattle on cold windy days could potentially affect woodland use by mule deer (Beaver and others 1996). Recent collaring of 11 mule deer will help investigate these interactions.

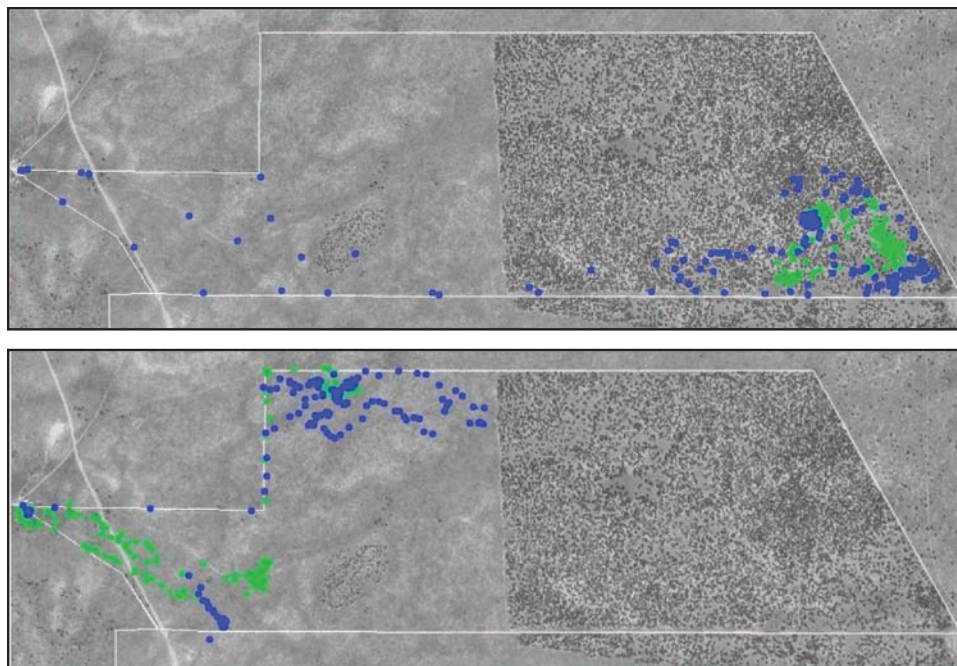


Figure 3—Horse pasture with cleared (left side) and intact PJ woodland (right side). Above: 5-minute interval location positions of one open and one nursing cow on a day with 29 °F wind chill corrected temperatures (March 4, 2004). Below: 5-minute interval location positions of same animals on a day with 47 °F wind chill corrected temperatures (March 17, 2004). The green points indicate 5 min-interval locations of a nursing cow. The blue points indicate the same but of a non-pregnant non-lactating cow.

Population Dynamics and Nutritional Ecology of Mule Deer on CRLRC

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Mule deer numbers in the State of New Mexico reached an estimated 302,000 in 1964 and have declined ever since. A combination of several factors may be responsible for the observed decline including local overpopulation, the aging of shrub habitats to less productive stages, drought, loss of quality fawning habitat, and increased predation. The presence of suitable habitat determines where and in what densities mule deer are found. Habitat management involves plant management. The two key points to plant management are: 1) knowing what plants are important for mule deer food and cover; and 2) knowing how to manipulate them. For rangeland and forest habitats in New Mexico, management tools may include livestock grazing practices, timber and brush management, water development, prescribed burning, and reseeding.

Mule deer on the CRLRC were subjected to a fee-hunting operation prior to New Mexico State University's acquisition of the area. The fee-hunting program continues to be operated with approximately 33 mule deer harvested annually. Data are collected from hunter-harvested males to assess trophy quality and body condition. Aerial surveys are used to estimate population size, age ratios, and sex ratios. The timing of these surveys allows determination of numbers of juveniles recruited. In addition, pre- and post-hunt spotlight surveys are conducted to estimate sex and fawn ratios.

Piñon-juniper modification has had a positive effect on mule deer numbers on the CRLRC. Past surveys indicated that mule deer utilize the areas treated with strip tebuthiron and the cleared areas the most. These results also suggested the

need to maintain early successional stages in the cleared areas since there has been an overall decline in mule deer use of cleared areas across the facility. Past surveys have also shown that woodland use by mule deer was relatively consistent through time compared to other vegetation types and treatments. This suggests maintaining much of the woody component on the Corona Ranch is important and excessive removal of juniper could be detrimental and cause a decline in deer numbers.

Management of Juniper Reinvasion into Previously Cleared Sites

Suppression of juniper invasion into previously cleared woodland sites has been a central concern of rangeland managers throughout western United States for several decades. Juniper invasion is associated with severe alteration of a number of hydro-ecological processes including reduction in the diversity and biomass of herbaceous plants, decline in habitat quality for wild and domestic ungulates, and major hydrological dysfunction in watersheds. Direct or indirect suppression of fire is thought to be the historical primary cause for this trend (Miller and others, 2005, and references therein). Although reinstatement of historical fire regimes has been proposed as a solution to juniper encroachment problems, controlled burns are often unfeasible for a number of biophysical and regulatory reasons. Alternative control methods such as herbicides or prescribed grazing have been used either in combination with fire or as fire surrogates.

Aggressive encroachment of oneseed juniper saplings can be observed on most cleared areas at CRLRC. Juniper reinvasion in these pastures has been partially suppressed using prescribed burns (in 2002) and herbicides (in 2004 and 2005). Understory vegetation response to chemical thinning of juniper woodlands in some of CRLRC's pastures has not been sufficient to provide necessary fine fuels to carry a controlled fire. Such sites offer unique opportunities to study the influence of fire surrogate treatments.

Prescribed Grazing by Goats and Sheep to Suppress Juniper Sapling Encroachment on Cleared Sites

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If prescribed grazing by sheep and goats is to be used as a successful fire surrogate, two basic conditions must be met: 1) juniper browsing intensity must promote rates of seedling and sapling mortality comparable to those observed after a burn; and 2) timing and duration of prescribed grazing events must allow levels of recovery of non target plant species similar to those observed after a fire. This research project focuses on aspects of the first basic condition.

Preliminary studies showed that oneseed juniper saplings at our research site synthesize over 50 volatile oils many of which are known to deter herbivory. Level of browsing intensity by sheep and goats is therefore, strongly constrained by the detoxification capabilities of their digestive systems. Free ranging ungulates cope with plant toxicity problems by continuously mixing nutrients and toxins, a strategy that allows them to feed on chemically defended plants that would otherwise be excluded from their diets (Provenza and others 2003). The objective of this project is to manipulate nutrient-toxin mixes to increase levels of juniper intake by goats and sheep thus augmenting their ability to suppress juniper sapling growth and recruitment.

Controlled pen trials currently in progress, will determine the effects of supplements on juniper intake (fig. 4). Additional trials with cannulated sheep are addressing the effects of juniper intake on the animal's rumen microbial population and its overall nutritional status. So far, data suggest that protein supplements can increase levels of juniper intake by both sheep and goats significantly and that the magnitude of this response is associated with rumen degradability of the proteins included in the supplement. Data also suggest that juniper ingestion has detrimental effects on most rumen microbial populations of sheep. Results from these pen experiments will be used to calibrate a field study to measure browsing impact on juniper sapling growth and survival.



Figure 4—Rambouillet ewe and Spanish-Boer cross nanny in juniper sapling pen feeding trials. Goats consumed significantly more juniper than sheep and supplements promoted a three-fold increase in juniper intake by both sheep and goats. (Photos: S. Utsumi 2005.)

Controlled Defoliation of Woodland Herbaceous Understory in Cattle Enclosures

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Impact of prescribed grazing on non-target vegetation is of critical importance to the success of a prescribed grazing program. The use of goats and sheep as a fire surrogate to suppress juniper sapling growth and recruitment must insure levels of recovery of non-target plant species similar or better than those obtained after a burn. This study involves simulating a single high intensity defoliation event of understory herbaceous vegetation during the dormant season. Aboveground biomass of grasses and forbs in plots under live and dead juniper trees (described above) is clipped to simulate a single heavy defoliation event (>70% utilization) during the month of February. Thirty-six plots in 3 grazing enclosures are included in this study. Half the plots will receive a single intense defoliation on 2 consecutive years (winters 2005 and 2006). Basal cover by species was determined prior to the beginning of this experiment and will be measured again in fall 2006 to determine treatment effects. The first defoliation event was applied prior to a spring with above average rainfall. Preliminary observations suggest that clipping treatment had no detrimental effects on the vigor of grasses and forbs within experimental plots.

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