Variation in Herbaceous Vegetation and Soil Moisture Under Treated and Untreated Oneseed Juniper Trees

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***Abstract**—Clearing oneseed juniper* (Juniperus monosperma) *may make more water available for aquifer recharge or herbaceous vegetation growth, but the effects of tree treatment on soil moisture dynamics are not fully understood. This study investigated juniper treatment effects on understory herbaceous vegetation concurrently with soil moisture dynamics using vegetation sampling, soil sampling, and automated precipitation and soil moisture data collection. The study was conducted at New Mexico State University's Corona Range and Livestock Research Center Corona, NM. We created plots under dead and live juniper trees in three cattle-grazing exclosures (CD, FG, and KI). We applied heavy defoliation clipping treatment and no defoliation in the winter months. This study reports on soil moisture from volumetric water content probes installed at 0-25 cm depth at the drip line or the outside of each plot. Understory herbaceous cover and biomass were significantly higher under dead than under living trees, while volumetric water content was lower under dead than under living trees. Water content was higher on clipped than on unclipped plots for dead and living trees. At this site, water made available by treating oneseed juniper appears to be consumed by additional herbaceous vegetation under dead trees.*

***Keywords:** volumetric water content, P-J control, understory defoliation, soil moisture dynamics.*

Introduction

Effects of clearing oneseed juniper woodlands on forage for cattle and big game have been extensively studied (Pieper 1990). However, less is known about the effects of such tree clearing treatments on soil water dynamics. In some locations, juniper clearing may be associated with groundwater recharge, while in others the water not used by trees may simply be consumed by herbaceous vegetation. According to Walter's model cited by Breshears and Barnes (1999), two soil layers may be distinguished on the basis of the rooting depths of plants (herbaceous and woody). Herbaceous plants have a denser root distribution than woody plants and are much more efficient obtaining water from the upper layer. Woody plants have sole access to the lower soil layer. Yet, some studies have shown that root depth to extract water depends on woody species (Montaña and others 1995) and competition for resources with herbaceous plants (Young and Evans 1981), although the distribution of plants varies with plant cover (Joffre and Rambal 1988) and depends on available soil moisture and nutrients (Breshears and Barnes 1999). Extensive research has been conducted on methods to remove piñon-juniper woodlands, yet much less is known about the sustainable management of cleared areas. Where juniper treatment increases understory herbaceous

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vegetation growth, prescribed grazing by goats and sheep may suppress juniper regrowth and improve ongoing recovery of herbaceous vegetation.

A straightforward approach to assessing juniper treatment effects on soil water dynamics is to identify understory herbaceous response and soil moisture content under treated dead and untreated live trees. To improve understanding of how juniper treatments affect understory herbaceous vegetation concurrently with soil moisture dynamics, this study investigated four aspects of vegetation and soil moisture response to juniper treatment: 1) the effect of juniper treatment on understory herbaceous vegetation cover and biomass; 2) the effect of juniper treatment on soil moisture under dead and live trees; 3) the soil moisture response to rainfall under dead and live trees; and 4) the soil moisture response to rainfall under dead and live trees where understory herbaceous vegetation had been subjected to a single high intensity defoliation event during the dormant season.

Materials and Methods

This study was conducted at New Mexico State University's Corona Range and Livestock Research Center also known as the Corona Ranch. Of the Corona Ranch, about half (5797 ha) has been classified as actual or potential piñon-juniper woodland. The herbicide Tebuthiuron was applied aerially to 959 ha in 1995, and tree mortality from the herbicide treatment was readily identifiable by the time of this study ten years later. Three cattle-grazing exclosures (C_t/D_u, F_u/G_t, and K_t/I_u) were selected for this study, with the subscript "t" indicating herbicide treatment and the subscript "u" indicating the untreated half of each exclosure. We created six plots under dead juniper snags and six plots under live juniper trees. Crown dimensions were used to delineate each rectangular plot with a long axis stretching under the largest axis of the crown and a short axis perpendicular to the long axis. All six plots per dead or live treatment were marked within a relatively small (~60 m diameter) area to reduce potential impacts of soil variation and to facilitate installation of an automated soil moisture sensor system.

We applied heavy defoliation (clipping treatment) and no defoliation (unclipped treatment) to aboveground biomass in February 2005. The purpose of the defoliation treatment was to imitate high intensity (>70% utilization) grazing by sheep and goats during the winter months. Six trees were defoliated in each exclosure: three were in the herbicide treated part of the exclosure and three were in untreated part of the exclosure. The remaining six trees were not clipped and left untreated. An additional defoliation treatment will be applied in winter 2006. Basal cover by species was determined prior to the beginning of this study with ten separate ten pin frames in each plot, including percent cover of bare ground, litter, and rock. Aboveground biomass by species was determined at the time of the basal cover measurements in plots that received defoliation. Superficial soil moisture content was determined in spring 2005 from 4x10 cm core samples taken at 1/3, 2/3, and 3/3 of the distance from the tree to the drip line along the short and the long axis of each plot. Each soil sample was stored in sealed plastic bags, weighed, oven dried at 105 °C for 48 hrs, and weighed again to determine water mass. With porosity from soil bulk density measured with a separate core sample, gravimetric water content was converted to volumetric water content (volume water/volume soil). Data were analyzed statistically in SAS using a completely randomized block design, with significant differences determined at $P \leq 0.05$.

For continuous soil moisture measurement, a nest of three CS616 (all Campbell Scientific Inc. equipment) volumetric water content reflectometer soil moisture probes was installed in each plot at the drip line on the outside of each plot at depths of 0 to 25 cm, 25 to 50 cm, and 50 to 75 cm. This paper reports on results from the surface layer, which corresponds to the herbaceous understory rooting depth. The CS616 probes were connected by cable to AM16/32 multiplexers, which in turn were connected to CR10X-2M data loggers powered by SP5-L five watt solar panels and PS100 batteries. In each exclosure, a TE525WS-L tipping bucket rain gage was installed and connected to the data logger to measure precipitation. Soil volumetric water content (volume water/volume soil) data were collected hourly from all locations beginning in September 2005. This study reports on continuous soil moisture in the period from September until November 2005, comparing time series of soil moisture averaged by dead, live, clipped, and unclipped treatments.

Results and Discussion

Juniper treatment significantly affected herbaceous understory vegetation. Basal cover of herbaceous understory was significantly different under live and dead trees ($P \leq 0.05$); it was about three times higher under dead trees (14.60%) than under live trees (4.64%) (table 1). There were also significant differences in vegetation basal cover between exclosures (table 1). Biomass was significantly different under dead and live trees, with much greater vegetation biomass under dead trees (59.52 $g \cdot m^{-2}$) than under live trees (17.91 $g \cdot m^{-2}$) (table 2).

The superficial volumetric water content exhibited significant differences between live and dead trees, being greater under live trees (10.36) than under dead trees (8.84) (table 3). There were also significant differences between exclosures

Table 1—Basal cover (%) under dead and live trees in three cattle grazing exclosures at the Corona Ranch. Values in each group with the same superscript letter are not significantly different ($P \leq 0.05$).

	Dead				Live				
Exclosure	Bare ground	Litter	Rock	Veg	Bare ground	Litter	Rock	Veg	Dead+Live Veg
CD	16.50	70.00	0.83	12.60	36.60	61.60	0.83	0.83	6.70^{b}
FG	10.50	70.50	0.00	19.00	9.50	80.10	0.00	10.30	14.60^{a}
KI	17.80	69.30	0.50	12.30	26.50	70.30	0.33	2.80	7.50^{b}
All exclosures	14.93	69.93	0.44	14.60^{a}	24.20	70.67	0.39	4.64^{b}	

Table 2—Biomass $g \cdot m^{-2}$ under dead and live trees in three cattle grazing exclosures at the Corona Ranch. Values in each group with the same superscript letter are not significantly different ($P \leq 0.05$).

	Tree treatment		Average by exclosure
Exclosure	Dead	Live	Average
CD	55.54	7.82	31.68^{b}
FG	83.99	32.82	58.40^{a}
KI	39.06	13.09	26.07^{b}
All exclosures	59.52^{a}	17.91^{b}	

Table 3—Volumetric water content (volume water/volume soil) under dead and live trees in three cattle grazing exclosures at the Corona Ranch.Values in each group with the same superscript letter are not significantly different (P ≤ 0.05).

	Axis of tree canopy		Distance from tree to drip line			Tree treatment		Average by exclosure
Exclosure	**Long**	**Short**	**1/3**	**2/3**	**3/3**	**Dead**	**Live**	**Average**
CD	10.82	12.21	11.79	11.76	11.00	10.90	12.13	11.50^a
FG	6.84	8.19	7.35	7.97	7.37	7.19	7.89	7.0^c
KI	10.96	8.52	9.69	9.98	9.54	8.43	11.05	9.70^b
All exclosures	9.54^a	9.64^a	9.61^a	9.90^a	9.30^a	8.84a	10.36^b	

(table 3). There were not significant differences in soil moisture by long or short plot axis or by distance (1/3, 2/3, or 3/3) from tree to drip line (table 3). Since these preliminary data showed no significant differences in soil moisture content at different locations under the tree canopies, recording soil moisture probes were located under the drip line to be representative of the tree to interspace continuum and to avoid interference with vegetation in each plot under each tree.

The September to November time period was opportune for characterizing soil moisture response to rainfall, because it came after at least four weeks without rain, allowing the herbaceous water consumption to be exhibited, and it included precipitation events then a period of drying into November. Comparing volumetric water content averaged for dead and live trees, the surface soil under dead trees was drier at the start of the period, rose higher than under live trees in response to rainfall, and dried faster than under live trees after rainfall (fig. 1). Comparing volumetric water content under dead trees that were clipped or unclipped, there was a muted response to rainfall, with slightly more wetting and faster drying seen on the clipped plots (fig. 2). Comparing volumetric water content under live trees that were clipped or unclipped, there was visibly greater soil moisture and slightly faster drying under clipped plots (fig. 3).

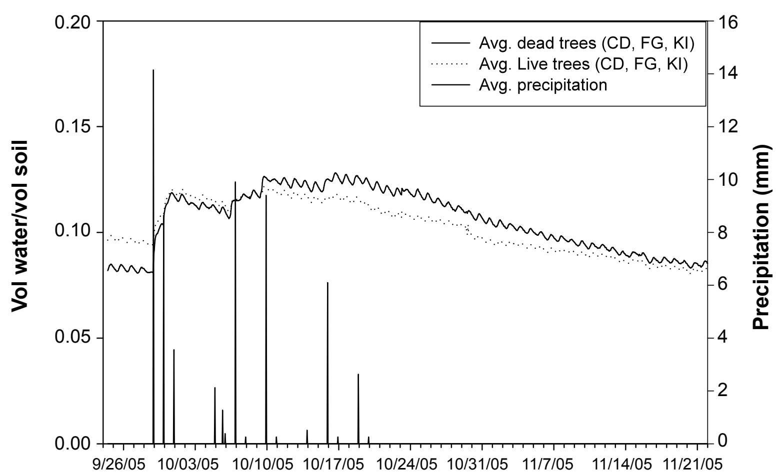

Figure 1—Soil volumetric water content response to rainfall beneath dead and living trees in CD, FG, and KI exclosures at the Corona Ranch.

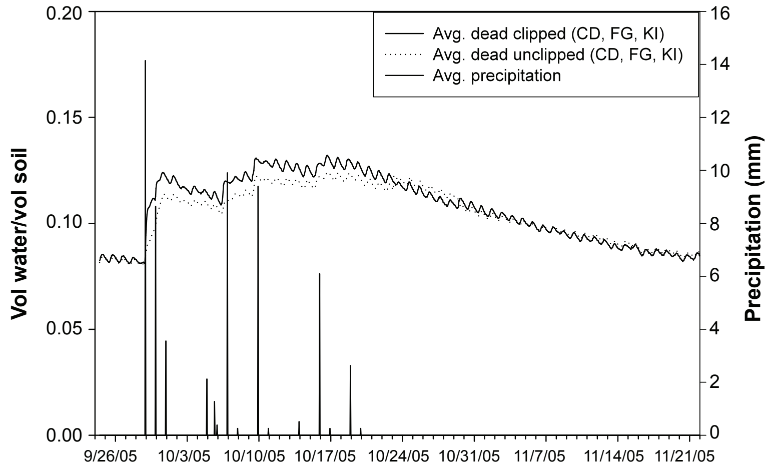

Figure 2—Soil volumetric water content response to rainfall under clipped and unclipped herbaceous vegetation beneath dead trees in CD, FG, and KI exclosures at the Corona Ranch.

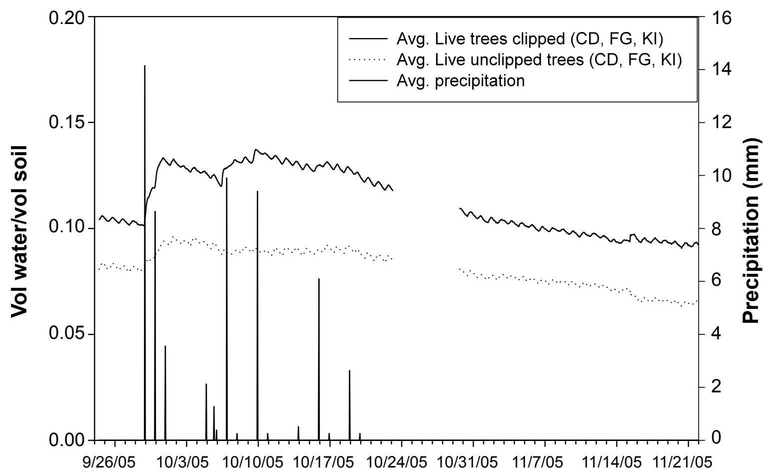

Figure 3—Soil volumetric water content response to rainfall under clipped and unclipped herbaceous vegetation beneath living trees on CD, FG, and KI exclosures at the Corona Ranch.

Understory herbaceous vegetation response to juniper treatment shows more vegetation under dead trees. At the same time, volumetric water content is greater under live trees, likely because there is less vegetative consumptive demand. In the time series comparing soil moisture, there was more rapid drying under dead trees, likely again because of the higher vegetative water consumption. Increased soil moisture after rainfall under dead compared to live trees may be from reduced rainfall interception under dead tree snags. At this site, water made available by treating oneseed juniper appears to be consumed, at least in part, by additional herbaceous vegetation under dead trees.

Clipping treatments in the dormant season did not seem to negatively impact vegetation vigor. Soil moisture time series were consistent with the interpretation that clipped vegetation grows back and consumes water as readily as or more readily than unclipped vegetation. The combination of herbicide treated trees and high intensity dormant season defoliation appeared to result in the most water consumption by herbaceous vegetation.

Conclusion

This study found that herbicide treatment of oneseed juniper resulted in greater understory herbaceous vegetation cover and biomass. While there were no significant differences in soil moisture under the area of the tree canopy, there were soil moisture differences between dead and live trees. Under dead trees, soil moisture increased more after rainfall, dried more quickly, and became drier than under live trees. Intense defoliation of the herbaceous vegetation seemed to follow a muted, but similar pattern as under tree treatment. Removing trees apparently makes more water available for herbaceous vegetation, that in turn consumes more water and with vigor unreduced by intense defoliation. While aquifer recharge may not be increased by juniper control at the Corona Ranch, tree treatment and intense dormant season grazing may result in ongoing improvements in the understory herbaceous vegetation as seen through the window of soil moisture dynamics shown in this study.

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