Research Article

Controlling One-Seed Juniper Saplings With Small Ruminants: What We Have Learned

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On the Ground

- Protein supplements and polyethylene glycol increased juniper intake by small ruminants in all seasons except fall, when PSM concentrations were greatest.
- Terpenes were affected by season and sapling size, and were related to juniper intake by small ruminants.
- Small sapling browsing occurred most frequently in summer. Debarking of branches on taller saplings was greatest in spring.
- Ten years later, juniper kill ranged from 5-14%. Growth suppression was still evident after 10 years; browsed saplings averaged 13 cm shorter than controls.
- Strategies to target grazing of one-seed juniper are more likely to succeed if aligned with periods when PSM are lowest.

Keywords: goats, phenology, plant secondary metabolites, protein supplementation, sheep, targeted grazing.

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Encroachment of woody plants onto rangelands poses serious management challenges to ranchers and land managers in New Mexico and throughout the western United States. One-seed juniper (*Juniperus monosperma*) dominates millions of hectares in New Mexico and Arizona.[1] Juniper clearing and/or chemical treatment have been used to encourage transition from degraded woodlands to savanna grasslands; however, sapling reinvasion is a major limitation of these practices. Targeted grazing may discourage reinvasion of undesirable woody species by suppressing seedling establishment.[2]

Woody plants commonly contain plant secondary metabolites (PSM) that reduce palatability and in some cases are toxic to livestock.[3] One-seed juniper contains a variety of PSM, including terpenes, phenolics, and condensed tannins.[4,5] Low intake of other juniper species by goats and deer has been related to terpene content.[6–9]

Supplements and additives may help overcome adverse effects of secondary compounds by replacing depleted nutrients or altering absorption or excretion of PSM. For example, polyethylene glycol (PEG) inhibits tannin-protein binding and can stimulate consumption of high-tannin shrubs by ruminants[10]; however, little is known about the effect of PEG on consumption of shrubs that contain both tannins and terpenes. Supplemental protein has also been shown to increase intake of shrubs containing terpenes.[11,12] Because PSM can impact processes in different locations within the animal (e.g., rumen fermentation and liver function), type of supplemental protein may affect their ability to cope with PSM. Rumen degradable protein (RDP) would be available to rumen microbes, while rumen undegradable protein (RUP) that bypasses the rumen may increase amino acids (AA) available to the liver for detoxification of absorbed PSM.

Other management decisions (e.g., choice of animal species, timing of use, stocking density) can affect shrub use as well.[13] Grazing systems that use heavy stocking and controlled allocation of forage can encourage animals to mix less preferred species into their diet and learn the value of complementary foraging.[14,15] Multiple species browsing may encourage juniper intake by goats through competition for forage resources.[16]

We conducted a series of studies to examine various mechanisms to increase juniper intake and to better understand the physiological effects of juniper consumption on the animal,[17–21] and to identify conditions in which targeted juniper use are most effective. We examined the role of season, sapling size, animal species, stocking density, and supplementation of nutrients and additives on juniper intake, PSM concentration, feeding behavior, and/or sapling mortality. The purpose of this synthesis is to 1) summarize key findings and make recommendations for enhancing use of one-seed juniper herbivory by small ruminants, and 2) to reassess juniper mortality 10 years after intensive browsing by sheep and goats.

Ten Years of Research in a Nutshell

All studies were conducted at Corona Range and Livestock Research Center (CRLRC) in central New Mexico or the New Mexico State University Campus Farm (NMSU) using juniper collected at the CRLRC. Experimental sites at the CRLRC were mechanically cleared of juniper in the late 1980s but are currently reinfested. Detailed methodology for all experiments (site characteristics, experimental design, sampling protocols, laboratory procedures, statistical analyses, etc.) have been reported previously.[17–21]

Briefly, a pilot study was conducted in the spring of 2005 to assess the PSM content of one-seed juniper saplings and to evaluate sampling and handling protocols.[17] Because juniper contains volatile terpenes, the pilot study was conducted to determine how length and temperature of storage prior to feeding affected terpene concentration.

A pen study was conducted at NMSU in 2005 to 2006 to examine the effect of supplemental protein (rumen degradable or bypass protein) on intake of juniper by sheep and goats.[18] Ewes and does were fed juniper for 10 days during all four seasons. Diets contained either high rumen degradable (RDP, 12.5% CP) or undegradable (RUP, 12.5% CP) protein or no supplemental protein (Control, 5% CP). Before feeding, juniper branches were fed ad libitum for 30 minutes.

A second pen experiment was conducted at NMSU in 2007 in which goats and sheep were fed diets containing juniper needles with sequential additions of protein, tannins, and PEG to determine mechanisms that limit intake of juniper in ruminants.[20] In four sequential periods, animals were fed the following: 1) basal diet (sudangrass hay) or basal diet plus RUP or RDP, 2) one-seed juniper, 3), quebracho tannins, and 4) PEG in addition to the preceding treatments. Animals received juniper in the morning followed by the basal diet plus treatment. Preference for juniper vs. the basal diet was evaluated after each period. Ruminal volatile fatty acids and plasma AA were measured.

A field study was conducted at the CRLRC during summer 2006 and spring 2007 to examine effects of goats or goats plus sheep at high or low stocking density on vegetation use during two seasons.[19,21] Groups browsed small paddocks either continually or rotated sequentially through subcells to alter stocking density. Feeding behavior was monitored and near infrared reflectance spectroscopy was used to estimate juniper in the diet. Frequency of debarking and defoliation and browsing intensity on saplings of different height classes were determined and related to terpene concentration. Understory vegetation was measured before and after each grazing period. In 2009, sapling canopy measurements (height, diameter, and volume) were repeated and mortality rates for saplings and branches were determined. Sapling canopy measurements, sapling mortality, and presence of new seedlings or saplings (recruitment) were measured again in early 2017. Data were then analyzed with a one-way analysis of variance in SAS 9.3 (SAS Institute, Cary, NC) to determine the effects of targeted grazing treatments (pooled across seasons) on sapling mortality, recruitment, and 10-year change in sapling density and height.

What We Found

The pilot study showed that juniper needles contain over 50 terpenoids that are highly variable from plant to plant.[17] Storage for up to three weeks did not cause significant loss of volatiles, which was important information because subsequent pen studies required harvest, transport, and storage of large amounts of plant material.

Juniper fed in the first pen study[18] contained >7% CP except spring (~6%), and together, phenolics and terpenes accounted for ~8% to 10% of needle DM. These PSM generally peaked in the fall, were lowest in the summer, and intermediate during winter and spring. Goats ate ~2.5-fold more juniper than sheep. Protein supplementation increased juniper intake about twofold in all seasons except fall, particularly in goats; protein supplements doubled juniper intake by goats and increased it by ~50% in sheep. Across species and treatments, animals ate ~40% to 60% less juniper in the fall (when PSM concentrations were greatest) than in other seasons. These results suggest protein supplementation may have increased juniper consumption via increased detoxification[11,12] or by negating negative effects of essential oils on ruminal protein metabolism,[22,23] except during fall, possibly because PSM concentrations during that period were too great for protein supplementation to counteract. Although voluntary intake of juniper seldom exceeded 5% of the total diet in this study, variation in juniper intake among individual animals within treatment, species, and season was high, suggesting selection for individual browsers could be a strategy to increase juniper intake. Low to moderate heritabilities for ashe and redberry juniper (*Juniperus ashei* and *J. pinchotii*) consumption by goats (13%)[24] and sagebrush (*Artemisia tridentata*) intake by sheep (25–28%)[25] suggest selection for one-seed juniper browsers could be a slow but inexpensive strategy to increase juniper consumption.

In the second pen study, basal diet intake decreased with juniper and tannin consumption in periods 2 and 3, and was partly restored with PEG supplementation in period 4.[20] Juniper intake differed among periods (~10, 10, and 20% of the total diet in periods 2–4, respectively). Sheep increased intake of juniper with time, whereas goats demonstrated a cyclic pattern of one to three days, similar to what Walker et al.[26] observed for free grazing goats. This cyclic intake in goats may be related to time needed for clearance of terpenes from the bloodstream.[27] These results support other research illustrating reduced intake in response to dietary PSM. In contrast to our first pen study, protein supplementation did not alter intake or preference for juniper, possibly because we used fall-harvested juniper (which contained the highest PSM levels in the previous study). Total volatile fatty acids and

Figure 1. Goats actively browsing one-seed juniper.

Figure 2. Bark-stripping by goats.

Figure 3. One-seed juniper skeletons after browsing by small ruminants.

acetate, propionate, and butyrate were highest in sheep and goats for period 2 with juniper and decreased in periods 3 and 4 when tannins were fed, suggesting juniper increased fermentation in both species, in contrast to our expectations. Although several monoterpenes typically found in juniper reduced fermentation by rumen bacteria from goats, α-pinene (which represents about 65% of the terpenes in one-seed juniper) doubled fermentation in that study.[28] A key finding was that juniper consumption reduced the concentration of several plasma AA (with and without dietary tannin); several AA remained low throughout the study, possibly because they were depleted during PSM detoxification.[3] Both protein supplements also helped restore blood levels of several AA. Some AA were also partially restored when PEG was fed, suggesting PEG supplementation may improve intake of woody species containing PSM by sparing protein and replacing AA used during terpene detoxification.

The grazing study[19] showed that goats actively browse one-seed juniper (Fig. 1) and that sheep spent about threefold less time browsing than goats in the same group (~8% vs. 25%). Browsing on juniper was also higher in summer than spring. Goats under the high-density stocking treatment spent a greater percentage of time browsing juniper than low density goats, especially in the mixed species treatment. A study in Utah[14] observed higher big sagebrush utilization by sheep with high stocking rates and rapid rotation through small paddocks vs. continuous grazing. Goats were more willing to mix juniper into their diet, especially in the high density mixed-species group, while sheep ate less juniper. Goats ate juniper more frequently and for longer periods of time in a given grazing bout. They may have used diet mixing[29] as a strategy to dilute PSM and allowed time for processing PSM between eating bouts. In a previous study,[27] sheep dosed with 1,8-cineole (a dominant monoterpene in sagebrush) stopped eating when it built up in the blood stream and resumed eating when cleared, which may explain the cyclic pattern of juniper intake in our study. Because goats on the low-density stocking treatment did not eat as much juniper early, the delay may have deterred them from learning about the benefits of mixing high- and low-PSM forages (i.e., complementary forages[15]).

Across all treatments and periods, herbaceous use ranged from 52% to 73%. Herbaceous use was higher with mixed species than goats only and higher for goats only in the low vs. high density treatment. About 88% of the short saplings in the mixed-species or high-density treatment were heavily defoliated. During the summer, branches from short saplings were used more (Fig. 2), while tall saplings were used more during spring (primarily via debarking). Across treatments, sapling size and level of use were inversely related. Across treatments, >60% of short juniper saplings were heavily used compared with ~45% of tall and medium saplings. Heavy debarking was more frequent on tall saplings (~55% of tall saplings exhibited a high degree of bark stripping whereas ~80% of the short saplings had light bark use).

Terpenoids accounted for almost 2% of the DM in the field study.[21] Bark had about half the concentration of terpenes as leaves. Terpenes in leaves were higher in spring than summer, and lower in short than medium or tall saplings. Junipers categorized as low, moderate, and heavy use varied in terpene concentration, with low use containing the highest concentrations and high use containing the lowest concentrations. Terpene concentration was inversely related to amount of browsing of short saplings. Both higher use of juniper in summer and higher use of short saplings suggest use was related to terpene concentration. Terpene levels have been related to consumption of other juniper species by browsing ruminants.[6–8]

Two years after completion of the field study, sapling mortality (Fig. 3) across treatments was about 5% and was not affected by treatment, while branch mortality from debarking ranged from ~13% to 22% across treatments.[19] Ten years afterwards, sapling mortality was higher ($P < 0.05$) in targeted grazing plots vs. controls and ranged from ~5% (high density goats) to 14% (high density goats and sheep) in treated plots (Table 1). Recruitment of new seedlings or saplings was ~4 % and was not different among treatments (Table 1). Growth suppression in targeted grazing plots was still evident 10 years after treatment, with browsed saplings about 13 cm shorter than controls. Although juniper kill and growth suppression 10 years after targeted grazing was modest in our study, it is possible that repeated targeted browsing on the same plots over multiple years may result in greater juniper mortality and growth suppression than observed in this study.

What Worked and What Did Not

If shrubs become increasingly expected to supply forage for ruminants as predicted,[13] it is crucial to understand the

Table 1. Effects of targeted grazing treatments on one-seed juniper sapling stands 2 and 10 years following treatment*

	2006–2007†		2009‡		2017§			
Treatment‖	**Sapling density (plants/ha)**	**Sapling height (m)**	**Mortality (%)**	**Sapling height change (m)**	**Mortality (%)**	**Recruitment (%)**	**Sapling density change (plants/ha)**	**Sapling height change (m)**
Control (no grazing)	566.7 ± 50	0.82 ± 0.11	0.0 ± 0.0†	0.08 ± 0.01*	0.9 ± 0.9†	3.5 ± 1.2*	17 ± 10*	0.34 ± 0.03*
Goats high density	633 ± 36	0.80 ± 0.04	4.0 ± 2.9*,†	–0.10 ± 0.04†	4.6 ± 2.0†	4.6 ± 1.2*	0 ± 7*	0.22 ± 0.03†
Goats low density	542 ± 75	0.82 ± 0.09	1.0 ± 0.8†	–0.10 ± 0.04†	7.4 ± 4.6*,†	4.1 ± 3.4*	–28 ± 33†	0.19 ± 0.01†
Goats + sheep high density	467 ± 96	0.85 ± 0.03	6.0 ± 2.6*	–0.16 ± 0.05†	14.0 ± 2.8*	4.6 ± 2.2*	–38 ± 11†	0.22 ± 0.01†
Goats + sheep low density	425 ± 41	0.87 ± 0.00	3.0 ± 2.0*,†	–0.12 ± 0.04†	4.9 ± 0.8†	4.0 ± 0.4*	–4 ± 4*	0.18 ± 0.05†

* Rangeland plots (20 x 30 m) were either not grazed (control) or grazed for 11 hours daily with 10 does (Goats) or five does and five ewes (Goats + Sheep) for 6 days either continuously (Low Density) or rotating daily through 10 x 10 m subcells (High Density). Each treatment was applied to two experimental plots in either summer 2006 or spring 2007 (means ± SEM for both seasons are shown). Plots were revisited in 2009 and 2017 to record sapling mortality rates, seedling/sapling recruitment rates and sapling crown dimensions.

† Pretreatment sapling density and height means ± SEM.

‡ From Table 7 in Utsumi et al.[19] (p. 383).

§ 2006 to 2007 pretreatment values were used to calculate changes in sapling density and height. Only live saplings that were present in 2006 to 2007 were used to calculate 2017 sapling height change.

‖ Different letters within a column indicate differences among treatments ($P \le 0.05$).

limitations of their use and to develop mechanisms to overcome these restrictions. Targeted browsing of short juniper saplings during summer may be most effective to cause growth suppression and minimize reinvasion. Targeted spring browsing of tall juniper saplings may be most useful for debarking and branch killing; girdling may be enhanced at higher stocking density. In the long term, high density browsing by sheep and goats together may lead to greatest juniper death rates. Supplemental protein and PEG may be useful for increasing juniper intake by goats, particularly during susceptible seasons. Fall is a poor time to target juniper use, and supplementation does not appear to be effective at that time. Designing systems to target juniper consumption by small ruminants during its most susceptible times that capitalize on diet mixing may allow for greater intake and suppression of juniper reinvasion without damage to the herbaceous vegetation or animal productivity. The combination of spring and summer grazing may have greatest impact on juniper suppression because of the distinct tissue (bark vs. vegetation) and sapling sizes affected. Collectively, these studies show that PSM content of junipers vary substantially among individual plants, as well as due to size and season; these chemical differences affect plant use and physiological responses (e.g., amino acid profile). Supplementation of protein and PEG, utilizing appropriate animal species and density, and targeting areas containing saplings of a particular height during the most vulnerable season may permit small ruminants to acquire nutrients and help reduce juniper encroachment simultaneously. These results also highlight the fact that because relative concentrations of PSM in species such as juniper are constantly changing in time and space, this chemical variability poses serious challenges to developing prescriptions that are consistently effective without considerable knowledge of the many factors that influence concentrations of aversive chemicals.

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References

1. Romme, W.H., C.D. Allen, J.D. Bailey, W.L. Baker, B.T. Bestelmeyer, P.M. Brown, K.S. Eisenhart, M.L. Floyd, D.W. Huffman, B.F. Jacobs, R.F. Miller, E.H. Muldavin, T.W. Swetnam, R.J. Tausch, and P.J. Weisberg. 2009. Historical and modern disturbance regimes, stand structures, and landscape dynamics in pinyon–juniper vegetation of the western United States. *Rangeland Ecology & Management* 62:203-222.
2. Launchbaugh, K., and J.W. Walker. 2006. Targeted grazing—a new paradigm for livestock management. In: Launchbaugh K, & Walker JW, editors. Targeted grazing: a natural approach to vegetation management and livestock enhancement. Englewood, CO, USA: American Sheep Industry Association. p. 2-8.
3. Estell, R.E. 2010. Coping with shrub secondary metabolites by ruminants. *Small Ruminant Research* 94:1-9.
4. Adams, R.P., T.A. Zanoni, E. von Rudloff, and L. Hogge. 1981. The southwestern USA and Northern Mexico one-seeded junipers: their volatile oils and evolution. *Biochemical Systematics and Ecology* 9:93-96.
5. Nunez-Hernandez, G., J.L. Holechek, J.D. Wallace, M.L. Galyean, A. Tembo, R. Valdez, and M. Cárdenas. 1989. Influence of native shrubs on nutritional status of goats: nitrogen retention. *Journal of Range Management* 42:228-232.
6. Riddle, R.R., C.A. Taylor, M.M. Kothman, and J.E. Huston. 1996. Volatile oil contents of ashe and redberry juniper and its relationship to preference by Angora and Spanish goats. *Journal of Range Management* 49:35-41.
7. Pritz, R.K., K.L. Launchbaugh, and C.A. Taylor. 1997. Effect of breed and dietary experience on juniper consumption by goats. *Journal of Range Management* 50:600-606.
8. Adams, R.P., J.P. Muir, C.A. Taylor, and T.R. Whitney. 2013. Differences in chemical composition between browsed and non-browsed *Juniperus ashei* Buch. trees. *Biochemical Systematics and Ecology* 46:73-78.
9. Adams, R.P., C.A. Taylor, T.R. Whitney, W.C. Stewart, and J.P. Muir. 2013. Goats and deer do not use terpenoids to select or avoid browsing on *Juniperus pinchotii* Sudw. trees. *Phytologia* 95:238-245.
10. Rogosic, J., R.E. Estell, S. Ivankovic, J. Kezic, and J. Razov. 2008. Potential mechanisms to increase shrub intake and performance of small ruminants in Mediterranean shrubby ecosystems. *Small Ruminant Research* 74:1-15.
11. Campbell, E.S., C.A. Taylor, J.W. Walker, C.J. Lupton, D.F. Waldron, and S.Y. Landau. 2007. Effects of supplementation on juniper intake by goats. *Rangeland Ecology & Management* 60:588-595.
12. Dziba, L.E., F.D. Provenza, J.J. Villalba, and S.B. Atwood. 2007. Supplemental energy and protein increase use of sagebrush by sheep. *Small Ruminant Research* 69:203-207.
13. Estell, R.E., K.M. Havstad, A.F. Cibils, E.L. Fredrickson, D.M. Anderson, T.S. Schrader, and D.K. James. 2012. Increasing shrub use by livestock in a world with less grass. *Rangeland Ecology & Management* 65:553-562.
14. Shaw, R.A., J.J. Villalba, and F.D. Provenza. 2006. Influence of stocking density and rate and temporal patterns of forage allocation on the diet mixing behavior of sheep grazing sagebrush steppe. *Applied Animal Behaviour Science* 100:207-218.
15. Provenza, F.D., J.J. Villalba, J. Haskell, J.W. MacAdam, T.C. Griggs, and R.D. Wiedmeier. 2007. The value to herbivores of plant physical and chemical diversity in time and space. *Crop Science* 47:382-398.
16. Animut, G., and A.L. Goetsch. 2008. Co-grazing of sheep and goats: benefits and constraints. *Small Ruminant Research* 77:127-145.
17. Utsumi, S.A., A.F. Cibils, R.E. Estell, and Y.F. Wang. 2006. Influence of plant material handling protocols on terpenoid profiles of one-seed juniper saplings. *Rangeland Ecology & Management* 59:668-673.
18. Utsumi, S.A., A.F. Cibils, R.E. Estell, S.A. Soto-Navarro, and D. Van Leeuwen. 2009. Seasonal changes in one-seed juniper intake by sheep and goats in relation to dietary protein and plant secondary metabolites. *Small Ruminant Research* 81:152-162.
19. Utsumi, S.A., A.F. Cibils, R.E. Estell, T.T. Baker, and J.H. Walker. 2010. One-seed juniper sapling use by goats in relation to stocking density and mixed grazing with sheep. *Rangeland Ecology & Management* 63:373-386.
20. Utsumi, S.A., A.F. Cibils, R.E. Estell, S.A. Soto-Navarro, L. Cheng, and D.M. Hallford. 2013. Effects of adding protein, condensed tannins, and polyethylene glycol to diets of sheep and goats

fed one-seed juniper and low quality roughage. *Small Ruminant Research* 112:56-68.
21. Estell, R.E., S.A. Utsumi, A.F. Cibils, and D.M. Anderson. 2014. Is differential use of Juniperus monosperma by small ruminants driven by terpene concentration? *Journal of Chemical Ecology* 40:285-293.
22. McIntosh, F.M., P. Williams, R. Losa, R.J. Wallace, D.A. Beever, and C.J. Newbold. 2003. Effects of essential oils on ruminal microorganisms and their protein metabolism. *Applied and Environmental Microbiology* 69:5011-5014.
23. Newbold, C.J., F.M. McIntosh, P. Williams, R. Losa, and R.J. Wallace. 2004. Effects of a specific blend of essential oil compounds on rumen fermentation. *Animal Feed Science and Technology* 114:105-112.
24. Waldron, D.F., C.A. Taylor, J.W. Walker, E.S. Campbell, C.J. Lupton, T.D. Willingham, and S.Y. Landau. 2009. Heritability of juniper consumption in goats. *Journal of Animal Science* 87:491-495.
25. Snowder, G.D., J.W. Walker, K.L. Launchbaugh, and L.D. Van Vleck. 2001. Genetic and phenotypic parameters for dietary selection of mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* [Rydb] Beetle) in Rambouillet sheep. *Journal of Animal Science* 79:486-492.
26. Walker, J.W., D.F. Waldron, E.S. Campbell, C.A. Taylor, C.J. Lupton, and S. Landau. 2013. Intermediate periodicities in juniper consumption and sampling strategies to accurately estimate the diet of free-grazing goats. *Rangeland Ecology & Management* 66:209-215.
27. Dziba, L.E., J.O. Hall, and F.D. Provenza. 2006. Feeding behavior of lambs in relation to kinetics of 1,8-cineole dosed intravenously or into the rumen. *Journal of Chemical Ecology* 32:391-408.
28. Broudiscou, L.P., A. Cornu, and A. Rouzeau. 2007. In vitro degradation of 10 mono- and sesquiterpenes of plant origin by caprine rumen microorganisms. *Journal of the Science of Food and Agriculture* 87:1653-1658.
29. Wiggins, N.L., C. McArthur, and N.W. Davies. 2006. Diet switching in a generalist mammalian folivore: fundamental to maximizing intake. *Oecologia* 147:650-657.

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