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MANAGING JUNIPER (CEDAR) WITH GOATS

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The expansion of juniper, commonly referred to as cedar, on rangelands is considered a major problem that reduces the value of the land and production of forage for livestock and wildlife. A commonly overlooked tool to manage juniper expansion is a prescribed goat-grazing plan. Goats, alone or in combination with other tools, can effectively reduce or manage the rate of juniper expansion. This publication will address general facts about goats and juniper, the problem of juniper expansion, and how to develop a goat management plan to mitigate the expansion of juniper. While cedar is a commonly used term among landowners for juniper species and the two are often used interchangeably, we will refer to cedar as juniper throughout this fact sheet.

THE TEXAS GOAT INDUSTRY

Goats were first introduced to Texas by Spanish Explorers in the 16th century. These goats, now referred to as Spanish goats, are used primarily for meat production and brush management. A major expansion of the Texas goat industry occurred when the Angora goat became popular. The Angora goat, known for mohair production, was brought into Texas in the 1850s at the Texas A&M University Sonora Experiment Station. By 1965, the goat population was estimated to be at 4.5 million, most of which were located in the Edwards Plateau region in West Central Texas. The Angora goat industry in Texas subsequently declined due to a diminishing market for mohair and the loss of the federal wool and mohair incentive program in the early 1990s. During this time, the Boer goat, known for its meat production, was introduced to Texas from South Africa. This breed was crossed with both Angora and Spanish goats. As of 2017, the majority of goats in Texas are meat goats, with an estimated population of 840,000.

FACTS ABOUT JUNIPER IN TEXAS

Juniper encroachment is one of the most pronounced environmental changes observed on Texas rangelands since the late 1800s, specifically throughout the Edwards Plateau region. Although junipers (e.g., redberry [*Juniperus pinchotii*] and Ashe [*J. ashei*]) are native to Texas, populations have expanded well beyond their historical ranges. The density and distribution of juniper have increased remarkably in the past 50 to 80 years. For example, from 1948 to 1982, redberry juniper distribution in Northwest Texas increased from 6 million to 10 million acres, while the distribution of Ashe juniper increased from 3.5 million to 6 million acres from 1985 to 1994.[1] Fire suppression, climate change, and overgrazing by livestock have all played a role in the expansion of juniper.

West and Central Texas are dominated by redberry juniper and Ashe juniper. Both species occupy rangeland throughout the Edwards Plateau, where they are used by livestock and wildlife during periods when other, more palatable forage species are unavailable. Junipers are usually dioecious, meaning most trees have all male or female flowers. Both redberry and Ashe juniper are evergreen trees that grow 18 to 20 feet tall with short trunks and scale-like leaves. The most distinctive difference between the two is the fruit, which is blue-green in Ashe juniper and copper-colored in redberry juniper. Ashe juniper is a non-sprouting species and is susceptible to fire, chemical, and mechanical treatments. Ashe juniper is typically multi-stemmed and has a broad globular growth form

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[1] Ueckert et al., 1997

that usually branches near the base. Its stems are often fluted and twisted, and as they age, turn a gray reddish-brown color. Redberry juniper is more difficult to control because it is basal-sprouting. It usually has several stems arising from the base to form a dense clump. The major distinction between the two species is the presence of white, wax-like flecks that are observable on the yellowish-green leaves of redberry juniper.

Redberry juniper is an opportunistic species that can rapidly expand into open savanna grasslands. Sufficient precipitation and favorable growing conditions are needed for the establishment of redberry juniper seedlings after germination and emergence. Successive years of above-average precipitation may increase redberry juniper seedling establishment in open savanna grasslands.* Redberry juniper establishment increases 50 percent during the second year of a 2-year period of above-average winter precipitation. Mature redberry juniper plants can serve as nurse plants or facilitate the establishment of other undesirable sub-shrubs. Algerita (*Mahonia trifoliolata* [Moric.] Fedde), littleleaf sumac (*Rhus microphylla* Engelm. ex A. Gray), lime pricklyash (*Zanthoxylum fagara* [*L.*] *Sarg.*), Mormon tea (*Ephedra viridis* Coville), prickly pear (*Opuntia* sp.), and juniper seedlings were found to be more present under the mature juniper canopies rather than between junipers in the Edwards Plateau. Some research suggests that large mesquite (*Prosopis glandulosa Torr.* var. *glandulosa*) trees facilitate the establishment of initial seedling redberry junipers on some Rolling High Plains sites on rangelands in Texas. Research has indicated that the soil directly underneath large, well-established, single-stem mesquite trees are considerably more favorable for redberry juniper growth and establishment than that in the interspaces because of enhanced soil nutrient redistribution due to the mesquite's extensive root system, leaf fall, nitrogen fixation, and partial shading.

EFFECTS OF JUNIPER ON OTHER COMMON PLANTS

Junipers have a debilitating impact upon the grassland plant communities they invade, and they can reduce the carrying capacity for livestock and decrease biodiversity for wildlife habitat. Research at the Sonora Experiment Station found that annual forage production (1,156 pounds per acre) on a low stony hill range site supporting 117 mature redberry junipers per acre is about 40 percent lower than the potential production of the site in the absence of mature junipers (1,909 pounds per acre). Estimated annual forage production when

*High precipitation years typically provide adequate fuel (extra grass) for a prescribed fire to manage new juniper expansion.

redberry juniper plants are mature is approximately 283 pounds per acre. Forage production typically decreases sharply until the juniper canopy cover is approximately 34 percent. The amount of residual litter from juniper leaves, twigs, and wood on a North Texas site supporting 300 mature redberry junipers per acre can be as much as 40,000 pounds per acre or almost 1 pound per square foot.

Competition for soil water and nutrients, shading, interception of precipitation, residual litter accumulation, and allelopathy—a chemical released by one plant or organism that negatively affects another plant species—are all potential explanations for the observed interference of mature juniper with the soil surface, grass vegetation, or herbaceous understory. Desirable native perennial grass species are typically inhibited or "choked out" due to juniper. Once established, juniper tree canopies typically grow together, blocking out precipitation and sunlight, preventing rainfall infiltration and other nutrients from reaching desirable grasses and forbs. Research has revealed that beneath juniper tree canopies, 55 to 97 percent of the soil surface is covered by a dense layer of dead juniper leaves. This deep layer of juniper leaves reduces native perennial grass establishment and growth, where desirable grasses are 65 to 90 percent lower than in interspaces, and total numbers of herbaceous species are only 60 to 72 percent as great as interspace areas. Research has shown the threshold at which perennial grass and forb production sharply decreases is 20 feet from the edge of mature juniper canopies to the juniper trunks. This sphere of negative influence from mature juniper trees is more extensive on shallow ecological rangeland sites with rocky and gravelly soils than on deep soils. The production of grasses and forbs increases only to the canopy edges or to 3 feet beyond the canopy edges of juniper removed on deeper clay loam soils.

GRAZING HABITS OF LIVESTOCK AND WILDLIFE

Livestock and wildlife are selective about what they eat. Cattle are typically grazers and prefer to eat grass. Goats are browsers and prefer to consume the leaves of woody plants. Sheep are intermediate feeders, which means they prefer forbs, such as herbaceous flowering plants or weeds, but commonly eat grasses and browse. Whitetail deer are most similar to goats. Grazing distribution can vary by species as well, since steep terrain is often preferred by sheep and goats but avoided by cattle. The distance from a water source is a major influence on grazing patterns, especially in dry, hot environments with large, extensive rangeland pastures.

FACTS ABOUT GOAT INTAKE OF JUNIPER

Goats will selectively browse on juniper, but the rate of browsing depends on many different factors. The most important is the age of the tree. Goats prefer juniper seedlings and juniper regrowth. Ashe juniper is typically selected at a higher rate than redberry juniper. Some reports indicate that Ashe juniper is browsed twice as much compared to the redberry species. Female trees are typically selected at a slightly higher rate than male trees. Goats will consume juniper throughout the year, but intake varies by season.[2] Much of this effect is due to the availability and palatability of other forages. For instance, during the winter, most other browse plants are dormant, which can increase the rate of juniper browsing. Protein supplementation has been shown to increase juniper intake in goats. It is also important to note that grazing behavior is a learned behavior. Much of this is taught to kid goats from their mothers. Therefore, goats reared in an environment without juniper are less likely to be effective at juniper control until this grazing behavior is learned. Herdmates also influence grazing behavior. The rate of juniper intake by an individual goat is likely to be improved if its herdmates are consistently browsing on juniper trees.

It has also been reported that purebred Spanish goats consume more juniper than purebred Angora and Boer goats. Additionally, researchers have shown that juniper intake is a heritable trait, and genetic selection for juniper intake can be improved with selective breeding of any breed or composite of breeds. Texas A&M AgriLife Research has selectively bred a line of goats based on the amount of juniper intake, which are referred to as "Super Juniper Eating Goats." These goats willingly consume and thrive on juniper as a major part of their normal diet. To do so, the animals must be genetically able to tolerate and digest the plant defense chemicals—called terpenes—that juniper produces to ward off grazers.

DEVELOPING A GOAT JUNIPER MANAGEMENT PLAN

On average, the commercial meat goat will have a diet of 20 percent juniper, but some have been known to eat as much as 50 percent. At 20 percent, the average goat (100 pounds) will eat around 0.6 pounds of juniper foliage per day. To calculate this: Multiply the body weight (BW) of the average goat by the estimated forage intake (3 percent of BW) multiplied by the percent of juniper in the diet. Then, multiply the daily intake of juniper of an individual goat by the size of the goat herd and the period of time the goat herd will be used in a particular pasture (Table 1). This will estimate the amount of total juniper to be harvested. We suggest that managers set a goal for the amount of juniper they wish to be harvested in a particular season. Remember that too many goats for too long of a period can be detrimental to the other rangeland forage species.

Table 1. In order to determine daily juniper intake, multiply the body weight of the average goat by the estimated forage intake (3 percent of BW) multiplied by the percentage of juniper in the diet. Then, multiply the daily intake of juniper by an individual goat by the size of the goat herd and the period of time the goat herd will be used in a particular pasture.

JUNIPER INTAKE	SIZE OF GOAT (LB.)		DIET (%)		JUNIPER (%)		DAILY JUNIPER INTAKE
Low	100	×	0.03	×	0.20	=	0.60 lb.
Moderate	100	×	0.03	×	0.35	=	1.05 lb.
High	100	×	0.03	×	0.50	=	1.50 lb.

Texas A&M AgriLife researchers recently evaluated two different methods for quantifying Ashe juniper biomass: 1) physical measurements obtained with field expedient methods and 2) three-dimensional canopy scans using laser technology.[3] Both methods were highly effective and are useful to inform stocking rate calculations for browsing animals. However, resource managers armed with little more than a tape measure and tablet can obtain readily usable information on juniper biomass for browsing or fire fuel planning. Basal diameter, maximum height, maximum canopy width, and canopy width perpendicular to the maximum are typically measured to build forage estimates based on tree size classes. All plant material from each tree and size class should also be collected. Plant tissue is dried to a constant weight at 140°F in a forced-air oven. From there, biomass relationships can be determined between forage measurements and canopy diameter,

[2]Launchbaugh et al., 1997
[3]Tolleson et al., 2019

canopy volume, and fuel category dry weights. As an alternative to the tape and tablet method, landowners can readily use data generated from Tolleson et al. to estimate forage availability of Ashe juniper based on the following height categories that were established from three-dimensional canopy scans using laser technology (Table 2).[3] The Ashe juniper composition data in Table 2 is reliable, well developed, and can easily be used as a reference for the respective height size classes.

Table 2. Data compiled from Tolleson et al. give examples of Ashe juniper composition, giving reliable estimates for Ashe juniper forage (pounds per tree) gathered from three-dimensional canopy scans using laser technology.[3]

ASHE JUNIPER COMPOSITION DATA				
	< 3 FT.	3–6 FT.	> 6 FT.	TOTAL
Trees/acre	100	50	10	160
Ashe Juniper Forage (lb./tree)	0.59	5.29	28.70	N/A
Ashe Juniper Forage (lb./acre)	59.0	264.5	287.0	277.2

ESTIMATED DAILY ASHE JUNIPER INTAKE PER GOAT*				
		LOW USE	MODERATE USE	HIGH USE
BODY WEIGHT (LB.)	DAILY INTAKE (3% BW LB.)	20% OF DIET	35% OF DIET	50% OF DIET
50	1.5	0.30	0.53	0.75
75	2.25	0.45	0.79	1.13
100	3.0	0.60	1.05	1.50
125	3.75	0.75	1.31	62.50
150	4.5	0.90	1.58	75.00
175	5.25	1.05	1.84	87.50

*Intake of juniper will vary from low to high use based on the availability of other forages, season, and individual goats, along with the sex, size, and species of juniper.

The next step in developing a juniper management plan is to determine the amount of juniper that needs to be harvested to manage juniper expansion. To calculate this, multiply the pasture size by the number of juniper trees by the amount of forage available per tree. Pasture size should be adjusted based on the area that is accessible to the goats. These calculations only take into account juniper that is available to goats and not the herbaceous component. When determining the number of trees, we recommend only counting trees that have forage available under 6 feet (i.e., a tree may have been previously used if a browse line is evident).

Goats will browse on the lower limbs of larger trees, but they will not suppress the tree with repeated browsing compared to smaller or younger trees. The final step is to estimate the amount of forage per tree.

Step 1. Determining the Number of Juniper Trees (Density)

1. **Mark off a plot size (see the table below).**
2. **Physically count the trees by size category:**
   - < 3 feet tall
   - 3 to 6 feet tall
   - > 6 feet tall
3. **To determine juniper density, multiply the counted trees in each size category by the respective plot size. An example length and width (feet) for each acre size given is also provided:**

PLOT SIZE, ACRES	APPROX. PLOT DIMENSIONS	MULTIPLY PLANT DENSITY BY:
1	209 ft. × 209 ft.	1
1/10	66 ft. × 66 ft.	10
1/4	104 ft. × 104 ft.	4
1/100	21 ft. × 21 ft.	100
1/1000	7 ft. × 7 ft.	1000

Step 2: Determine the Amount of Juniper Accessible to Goats

NUMBER OF JUNIPER TREES (TREES/ACRE)		FORAGE PER TREE (LB./TREE)		TOTAL JUNIPER FORAGE (LB./ACRE) (*USE TABLE 2 FOR REFERENCE)
10	×	1	=	10 lb.
10	×	10	=	100 lb.
10	×	25	=	250 lb.

Tolleson et al. completed this work and built a practical example of using biomass calculations to determine the amount of Ashe juniper forage available on a given land area or management unit.[3] Tolleson et al. then used this information to calculate a stocking rate for goats (Table 3).[3] Using this information, a landowner could estimate a beginning stocking rate for goats on typical Edwards Plateau rangeland. For instance, we could estimate that a 495-acre pasture with 719 pounds of juniper and 500 pounds of herbaceous standing crop per acre (1,219 pounds per acre of total forage available) and a 25 percent utilization efficiency could provide grazing or browsing for 362 100-pound goats for 90 days.

Table 3. Based on three-dimensional canopy scans using laser technology, Tolleson et al. built a practical example of using biomass calculations to determine the amount of Ashe juniper forage available on a given land area or management unit. Then, they used this number to calculate a stocking rate for goats.[3]

	JUNIPER TREE COUNT IN 0.25 ACRE				JUNIPER FORAGE LB./0.25 ACRE			
PASTURE	< 3 FT.	3–6 FT.	> 6 FT.	TREES/ ACRE	< 3 FT.	3–6 FT.	> 6 FT.	JUNIPER FORAGE LB./ACRE
1	29	15	25	279	17.6	80.3	725.7	823.6
2	13	5	1	77	7.8	26.8	29.0	63.6
3	52	5	9	267	31.4	26.8	261.4	1319.6
4	13	6	5	97	7.8	32.1	145.2	185.1
5	71	17	39	514	43.0	91.0	1132.2	1266.2
6	83	23	40	591	50.2	123.3	1161.2	1334.7
7	62	13	18	376	37.5	69.6	522.5	629.6
8	48	23	36	433	29.0	123.3	1045.0	1197.3
Average				**329.3**				**727.5**
Standard Error				**65.4**				**179.3**

The next step is to calculate the number of goats and the length of time required by a goat herd to harvest the desired amount of juniper to reach the desired management goal. To get started, land managers should set a time period that goats will be allowed to graze within a year. Then, divide the total juniper harvest desired by the length of the goat grazing season. This calculation will provide the number of juniper forage in pounds per acre per day to determine the grazing time for the landowner's goals.

Step 3: Determine the Stocking Rate Needed

TOTAL JUNIPER (LB./ACRE)	JUNIPER INTAKE (LB./DAY)	GRAZING TIME (DAYS)	GOATS PER ACRE (HEAD/ACRE)
100	1.5	100	0.66
100	1.5	200	0.33
100	1.5	365	0.18

The final step is to determine if there is adequate forage available from other plants to support the goats and other livestock on the ranch. The goal of the prescribed goat grazing plan is to reduce juniper and allow for other plants to increase. However, if this plan overstocks the land, the other desirable plants will be foraged upon too frequently to be able to thrive, thus causing harm to the rangeland. To accomplish this, we suggest that landowners seek assistance from skilled rangeland managers who can evaluate the range condition and determine if the intended goat stocking rate is reasonable. As a general rule, if the ranch is raising primarily beef cattle, then one goat per cow on an annual basis will not likely have any negative impact on the rangeland. If you are currently grazing cattle and juniper production is not included in your calculation of forage for cattle, you could contribute the entire complement of the juniper to the goat stocking rate. However, there is likely more overlap of the goat diet into the cattle herbaceous than the cattle diet into the juniper consumption. Therefore, you may need to reduce the goat stocking rate to account for the diet overlap. To calculate this, multiply the goat stocking rate by the percent grazing season on an annual basis multiplied by the estimated number of goats per animal unit (1,000-pound cow with a calf less than 6 months old). Then, divide this number by the number of suggested acres per animal unit that the rangeland has been determined to support. If this number exceeds 10 percent, then it is suggested to reduce the stocking rate of other grazing ruminants by this percent. If this number exceeds 100 percent, goats may not be an option to control the expansion of the juniper without the addition of another juniper management tool.

Step 4: Evaluate the Stocking Rate

GOATS (HEAD/ ACRE)		SEASON (% OF YEAR)		GOAT AU (HEAD/ AU)		SUGGESTED STOCKING RATE (ACRES/AU)		PERCENT OF NORMAL (%)		
1.25	×	0.27	×	7	/	30	×	100	=	7.875

Stocking Rate Calculation Example

	< 3 FT.	3 TO 6 FT.	> 6 FT.	TOTAL
Trees per acre	100	50	10	160
Lb. forage per tree	0.14	3.75	17.1	2.33
Lb. per acre	14.0	187.5	171.0	372.5

Acres in pasture	500
Juniper forage/acre, lb.	372.5
Total lb. juniper forage	186250
% Utilization	0.25
Juniper forage utilized, lb.	46563
Dry matter intake lb. juniper	1.25
Grazing period (d)	90
Dry matter intake/period	113
Number of goats	414

FIRE AND GOATS

Fire originally suppressed juniper. With adequate fuel, such as more than 1500 pounds per acre of dormant grass, fire will top-kill redberry juniper less than 6 feet tall and will cause direct mortality on Ashe juniper. Unfortunately, many junipers have grown so large that prescribed fire is no longer an effective management tool due to minimal understory fine fuel loads. Prescribed burns may be effective for mature juniper trees during intense summer fire prescriptions. While not the best choice to eradicate large, established trees, prescribed fire can be used to control young juniper. For larger trees, chemical or mechanical control methods should be integrated into the prescribed fire plan. Fire followed by goat grazing is a very effective combination of low-cost management strategies. For example, if fire is utilized to top-kill redberry juniper and is followed by re-sprouting at the plant crown base, the new immature growth is typically more palatable for goats and other small ruminants to browse.

SUMMARY

Prescribed goat grazing can be a very effective tool to reduce the density or control the spread of juniper, especially if done in combination with other juniper control methods, such as fire. The prescribed grazing of goats requires planning, continual monitoring, and sustained effort over many years to achieve a substantial reduction in juniper density. In some cases, prescribed grazing must be done indefinitely to control juniper expansion. Additionally, in some scenarios, juniper density may be too high for prescribed grazing to be effective. However, goats are often the most economical tool to manage juniper from expanding on native rangeland. If managed properly, the goat herd will generate a profit while improving the land. For a juniper control goat management plan to be successful, it is very important that landowners or contract grazers have extensive knowledge of land and livestock management.

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