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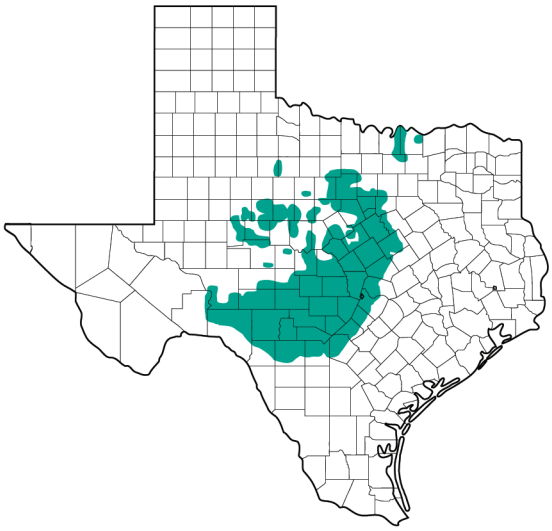
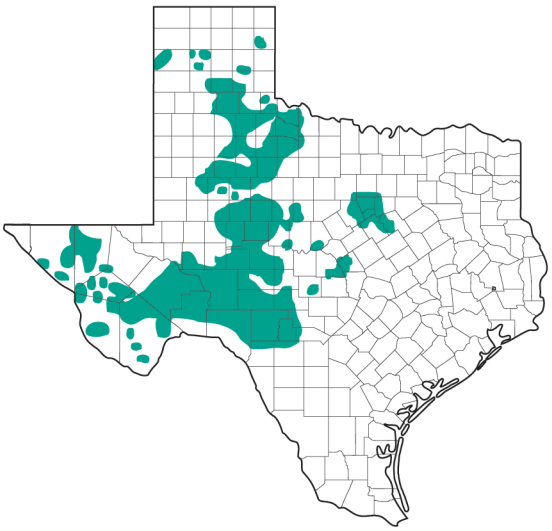
Juniper Biology and Management in Texas

Ashe Juniper



Redberry Juniper



Juniper Biology and Management in Texas

Robert K. Lyons, M. Keith Owens and Richard V. Machen*

Junipers, or cedars as they are commonly known across much of Texas, are a major management concern on rangelands. With changes in the economy and in management objectives of landowners, and with increasing emphasis on water quality and conservation, this concern is broader and more complex than ever before. Juniper management today is approached not only from the perspective of traditional livestock management, but also considers rangeland watershed management, wildlife habitat management, and protection of endangered plant and animal species.

Juniper Species and Distribution

Six species of junipers occur within the state, but only three species are prevalent enough to cause management problems. Eastern red cedar *(Juniperus virginiana)* occurs in the eastern part of the state, while the other two major species—ashe juniper *(Juniperus ashei),* also known as blueberry cedar, and redberry juniper or cedar *(Juniperus pinchotii)*—occur in the western two-thirds of the state.The latter two species are the focus of this publication. Much of the information about ashe juniper is also true of eastern red cedar.Ashe juniper is most common on the eastern and southern portions of the Edwards Plateau. Redberry juniper is found on the northern and western portions of the Edwards Plateau, west into the Trans Pecos, and north into the Rolling Plains, High Plains, and Cross Timbers and Prairies.

Juniper Biology

Physical Characteristics

Ashe and redberry juniper have both similar and different growth habits (Table 1). One of the most important differences is the way they sprout. Ashe juniper typically has a single trunk and does not sprout if the top is removed. Redberry juniper is multi-stemmed and sprouts from a bud zone at the base if the top is removed. Ashe juniper tends to have

Table 1. Physical and growth characteristics of ashe and redberry juniper.

Characteristic	Ashe juniper	Redberry juniper
Basal sprouting	no	yes
Bark color	gray to reddish brown	ashy-gray
Bark texture	shredding	cracked lengthwise into scales
Trunk	single	multi-stemmed
Sapwood	white	white
Heartwood	pale brown	light brown to reddish
Fruit	blue	reddish or copper brown
Leaves	no wax	small wax-like flecks present
Season of growth	evergreen	evergreen
Growth form	rounded from base	uneven canopy shape
Mature height	15 to 30 feet	less than 15 feet
Mature canopy diameter	less than 12 feet	less than 12 feet
Separate male and female plants	yes	yes

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a rounded growth form, while redberry is more irregular in shape. The small, white, wax-like flecks on the leaves of redberry juniper are an important distinguishing characteristic between these two species. Both species have separate male and female trees. In both species leaves on mature branches are scale-like, while leaves of young shoots and seedlings are spiny and awl-shaped. These differences can affect biological control, as discussed later.

Berries and Seeds

Ashe juniper flowers release pollen from December to February. Berries develop until November and ripen and disperse from November to April. Redberry junipers pollinate in September, October and November; berries disperse from November to January. Berries are eaten by most mammals, many bird species, and some insects.

Ashe junipers begin to produce berries when trees are about 3 to 4.5 feet high, or about 10 to 20 years old. Large trees can produce 100,000 to 250,000 berries per year. Precipitation appears to control berry production. Berries ripen at the same time on a single tree, but ripening among trees differs. This pattern keeps animals that disperse the seed around for a long time. If not picked up by an animal, berries stay close to the parent tree. Although seeds have low viability, the number of seeds produced compensates for this. Germination increases when berries are eaten by animals and the seed passes through the digestive system. Under field conditions, seeds are viable for only about 18 months. With both species, seeds germinate and emerge best in a wet spring or fall.

Seedlings

Ashe juniper seedling density is greater under female juniper trees than under oaks or on open grassland. Female junipers provide a good establishment site and protect seedlings somewhat from large herbivores. Removing large juniper trees can release these seedlings and promote their rapid growth, so follow-up seedling management is necessary.

Even redberry junipers, which are a sprouting species, appear to be weak competitors during establishment. With this species, clipping at ground level, below the bud zone, kills nearly all seedlings and saplings less than 8 years old. The bud zone (Fig. 1) is usually covered by soil by 8 to 12 years of age. Therefore, redberry juniper trees less than 8 years old can be killed by grassland fire and cutting at ground level. At 8 to 12 years of age upland trees are about 18 to 24 inches tall, while trees on deep soils may be 25 to 37 inches tall.

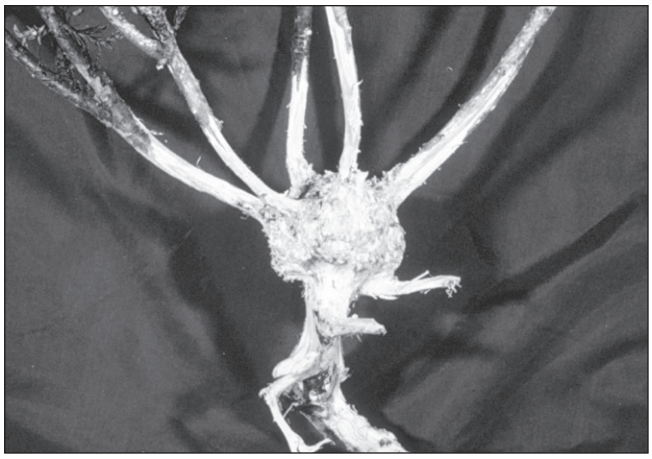

Figure 1. Redberry juniper bud zone, which allows this species to resprout after top removal (courtesy of Dr. Darrell Ueckert, Texas Agricultural Experiment Station, San Angelo).

Juniper Plant-Animal Ecology

Junipers are a concern because they can reduce grazable area for livestock and wildlife, reduce production and diversity of plant species, restrict access to desirable forage plants, and reduce rainfall effectiveness.

The effect of juniper on livestock and wildlife can be great. One example (Table 2) indicates that with a closed juniper canopy, forage production would be reduced from 1,900 pounds per acre to 283 pounds per acre. This would result in a 675 percent increase in acres required per animal unit (one 1,000-pound

Table 2. Estimated reduction in livestock and wildlife carrying capacity for a range site near San Angelo in relation to increasing redberry juniper densities.

Productivity	No juniper	Partially closed canopy	Closed canopy
Forage production, lbs./acre	1,900	1,156	283
Carrying capacity, acres/animal unit year	20	33	135
Increased acres required per animal unit year, %	0	165	675

cow consuming an average of 26 pounds of forage dry matter per day over a production year).

Junipers interfere with grass and forb production by intercepting rainfall before it reaches the ground and by out-competing other plants for water, nutrients and sunlight. Junipers appear to be heavy users of soil nitrates. Therefore, soil near junipers may be less favorable to the growth of other plant species. Mature redberry juniper trees reduce the yields of grasses and forbs dramatically from the trunk out to 20 feet beyond the edge of mature tree canopies on shallow soils. However, on deeper clay loam soils, this area may only extend to 3 feet beyond the canopy edge.

Grass and forb production and species diversity are severely reduced under junipers. Accumulation of litter under the trees appears to be the primary reason for this reduction, although there is no evidence that this litter changes the chemical nature of the soil. Instead, the effect appears to be due to changes in hydrological properties under the canopy. Litter intercepts and absorbs moisture from light rainfall so that less surface soil moisture is available under the canopy for the growth of grass and forbs. The understories of browsed plants have more light, less litter, and generally more grass and forb production and diversity than those of unbrowsed plants.

No single factor is responsible for the increase in juniper that has occurred since European settlement. Although grazing is often mentioned as a primary cause, it is clear that juniper woodlands would not revert to grasslands if grazing were eliminated. The natural grassland fires that occurred periodically before European settlement kept junipers in check. Suppression of these fires by early settlers and by livestock overgrazing contributed to the increase in juniper. There is further proof that grazing alone did not cause the increase in juniper density in the fact that areas excluded from grazing for many years have increased in juniper density. Extended droughts, which can significantly influence the amount and kind of woody plants, appear to favor juniper increases.

Rangeland Watershed Management

Water is a major concern in Texas, and rangeland watersheds are major sources of water in the state. As rangeland vegetation changes from grasses to trees, a greater proportion of rainfall is intercepted and evaporates, and there is less rainfall available for grass and forb production, deep percolation, or runoff. Junipers are a major concern in this regard.

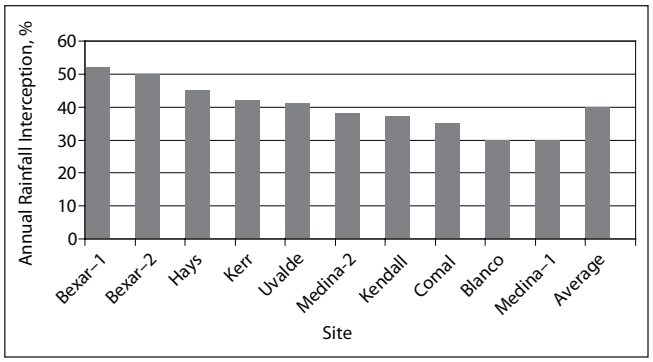

Figure 2. Annual ashe juniper combined canopy and litter rainfall interception at ten study sites (Owens, unpublished data).

Rainfall can be intercepted and lost both within the plant canopy and plant litter. Thurow and Hester (1997) reported canopy interceptions by average-size, mature trees of 26 percent for redberry juniper, 25 percent for live oak, and 37 percent for ashe juniper. Owens et al. (2006) reported combined canopy and litter interception averaging 40 percent across 10 sites (Fig. 2).

Using this interception level, a 24-inch rainfall area would actually receive 14.4 inches at ground level beneath ashe juniper trees. Most rainfall of less than 0.1 inch does not even reach the litter layer because it is intercepted by the tree canopy (Owens et al., 2006). Owens et al. also calculated the potential interception loss within ashe juniper communities with tree canopy cover ranging from 20 to 100 percent (Fig. 3).

Figure 3 illustrates these calculations for the wettest (Bexar-1) and driest (Kerr) study sites and for the average across all ten sites. At 20 percent juniper

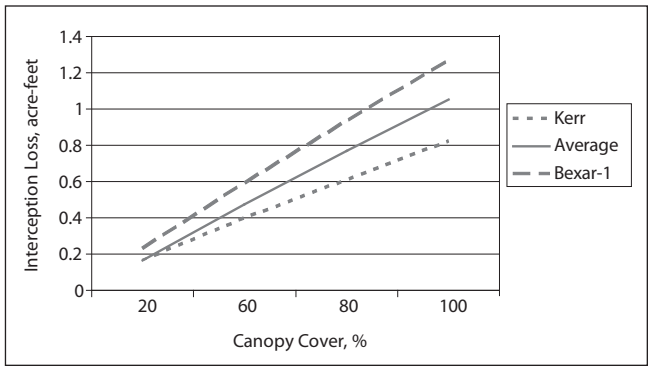

Figure 3. Calculated annual rainfall interception by tree canopy and litter within ashe juniper communities at different degrees of tree cover for the wettest (Bexar 1), driest (Kerr), and average of all ten sites in the juniper rainfall interception study. Adapted from Owens et al. 2006.

cover, about 0.2 acre-feet of rainfall interception by the canopy and litter would be expected. Overall, at 100 percent cover (cedar break), the average expected interception would be 1.05 acre-feet (342,000 gallons). At the Kerr site, the expected interception would be 0.82 acre-feet with 100 percent cover. Therefore, an 80 percent reduction in juniper cover from a 100 percent level at the Kerr site, would be expected to increase water at the soil surface by 0.71 acre-feet (231,000 gallons).

Stemflow, which is precipitation that falls on vegetation cover and is channeled by branches to the trunk, gives some plants a competitive advantage. With redberry and ashe juniper, stemflow allows these species to receive 470 percent and 462 percent, respectively, of the annual rainfall at the bases of their trunks.

Rainfall infiltration rates are often highest under trees and shrubs because their cover breaks the erosive force of raindrops, their litter reduces runoff, and litter improves soil structure so that water can enter the soil more easily. Junipers harvest runoff water from the areas between trees because of the greater infiltration rate beneath their canopies. This phenomenon explains why: 1) runoff may not increase or decrease as juniper density increases after a certain point; 2) the area near the dripline usually has greater forage production many years after tree removal; and 3) runoff will not necessarily increase greatly when juniper is removed. Once trees are removed, water continues to infiltrate at high rates into soils that were under junipers because of the improved soil structure. This effect may actually increase deep percolation (downward movement of rainfall into underground aquifers). When juniper trees are present, much of the precipitation never reaches the soil and the trees extract most of the water that does enter the soil and then transpire it into the atmosphere.

Junipers protect the soil beneath their canopies. However, the areas between trees have more potential for erosion. There are two reasons for this. First, junipers compete strongly with grasses in these areas. Second, increased grazing pressure in these areas removes protective grass cover.

Juniper root systems also affect rangeland water. These plants have extensive lateral and deep roots, dense fibrous roots at the soil surface, and root adaptations for extracting water from dry soil. Their roots make them strong competitors under the canopy and in the areas between trees. Their root systems give them access to a greater volume of water than grasses or forbs. Because they are evergreens, junipers can accumulate energy and transpire all year. Their dry-soil root adaptations allow them to remove water long after grasses and forbs are dormant because of drought or high temperatures.

Juniper and Wildlife

Food and Cover

Junipers can provide both food and shelter for wildlife species. The specific use and value of juniper depends on the wildlife species and the amount of juniper available compared to other, more desirable plants.

Juniper is only fair as a deer forage in terms of nutritional quality (Table 3), but deer may eat substantial amounts of juniper berries and foliage when desirable browse is unavailable. In late winter, up to 50 percent of a deer's diet may be juniper. Juniper berries also are eaten by coyotes, gray fox, ringtail, raccoons, rabbits and rodents. They are most important to robins and cedar waxwings.

Table 3. Chemical composition of juniper foliage.

Ingredient	Percentage of dry matter
Crude protein	5 to 10
Digestible organic matter	48 to 70
Cell wall	31 to 34
Phosphorous	.07 to .15
Ash	3 to 7

Juniper provides wildlife species with thermal, escape, nesting, loafing and screening cover. Thermal cover protects animals from extreme temperatures. Juniper trees provide thermal or escape cover for deer, quail and other species. As thermal cover, juniper is most important to deer in winter. As escape cover, juniper is no more valuable than any other brush species with appropriate density and canopy structure. Escape cover requirements depend on topography, human disturbance, brush density, and wildlife species. Several bird species, including wild turkeys, cardinals and golden-cheeked warblers, use juniper as nesting habitat. It is not preferred loafing cover for bobwhite quail.

Effects of Control

Controlling juniper affects wildlife species in different ways, and the effects largely depend on the amount cleared. Studies with deer (Rollins, et al., 1988) showed that 50 to 70 percent of a pasture could be cleared in 20-acre clearings (about 200 yards wide and 500 yards long) with 70 yards of brush left between clearings, without harming deer populations. In fact, clearing up to 70 percent of the brush improved deer distribution across the habitat. Clearing small areas (2 acres or less) results in intense grazing pressure. (If shinoak is present, juniper slash piles can be placed on the shinoak for burning to stimulate regrowth which is readily used by deer.)

Jackrabbits and some bird species may increase as juniper is cleared.

The only endangered species that requires juniper is the golden-cheeked warbler. Golden-cheeked warblers are often found in closed canopy ashe juniper-oak woodlands along streams and/or canyon slopes in the eastern part of the Edwards Plateau. Deciduous hardwoods associated with the ashe juniper provide insects for feeding, nest sites and perches. The golden-cheeked warbler requires shredding bark from mature ashe juniper to build its nest.There are no records of this bird being associated with pure stands of redberry juniper. Black-capped vireos do not require ashe juniper, but use plants associated with the juniper such as shinoak, Texas persimmon and sumac. The Endangered Species Act must be considered before ashe juniper is cleared. Thirty-three counties are currently designated as potential golden-cheeked warbler habitat. At present, stands of juniper less than 10 feet tall do not constitute critical habitat and can be cleared. However, several other criteria should be considered, including the possibility of habitat fragmentation.

Fragmentation occurs when large blocks of suitable habitat become smaller and are subdivided. The size of fragmented habitat or its location relative to additional habitat may not be suitable for many wildlife species.

To enhance and protect wildlife habitat and to increase or maintain the real estate value of your rangeland, consider brush sculpting rather than brush clearing. Sculpting includes:

- Following land contours and avoiding long, straight lines.
- Keeping brush on hilltops and along drainages.
- Marking and keeping brush species such as Texas oak, bumelia and hackberry.
- Leaving scattered mottes of brush within clearings.

Juniper and Livestock

Juniper foliage contains relatively high nutrient levels (Table 3). Crude protein and phosphorous levels, although not high, remain relatively stable during drought or cold weather. Digestible organic matter levels indicate that energy content is equal to most hays.

However, livestock eat only limited amounts of juniper because it contains volatile oils. Evidence that these oils are the reason for low consumption is that dried, ground juniper is almost entirely palatable because the oils have volatilized. These oils have no known metabolic use in junipers but appear to function as a defense against herbivores and an attractant for specific insect pollinators.Although these oils can be extremely toxic to rumen bacteria, they are not a serious problem because such small amounts of juniper are eaten, oils are diluted by chewing and rumination, and absorbed oils are detoxified by the liver.

Each juniper species has a unique combination of volatile oils, but the actual amount of each oil is affected by the environment. The types of oil and their relative proportions appear to influence which juniper species, which age of plants, and which individual plants are eaten by livestock. Oil content is lower in young juniper than in older juniper growth; consequently, goats prefer juniper seedlings and regrowth to mature growth. Goats regularly return to the same trees to harvest young regrowth. Leaf material appears to become less palatable as foliage ages. The specific volatile oils responsible for animal preference appear to be alcohols. Two of these alcohols have greater concentrations in redberry than in ashe juniper (Fig. 4).

Goats have been found to eat three to five times more ashe than redberry juniper. General goat juniper preferences in decreasing order are ashe female, ashe male, redberry female, and redberry male.

Goats may be able to detoxify juniper oils better than other livestock. Spanish goats have shown less liver damage from juniper consumption than Angora goats, and Spanish goats consistently eat more juniper than Angoras.

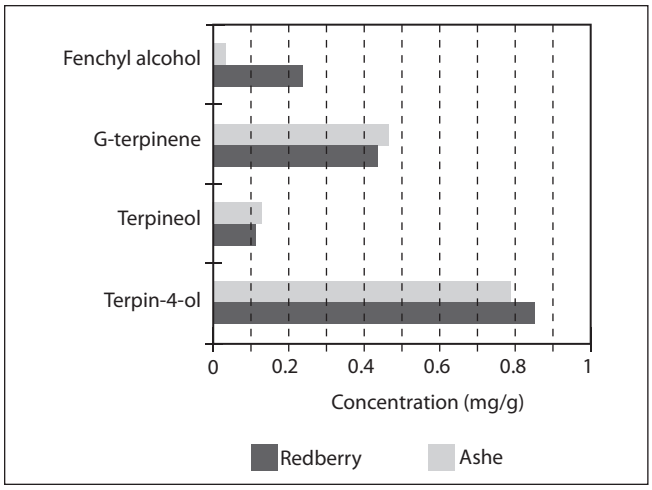

Figure 4. Volatile oil concentrations in ashe and redberry juniper. (Note: Terpin-4-ol and Fenchyl alcohol are thought to be responsible for differences in animal preference between the two juniper species.)

Juniper Management

The amount of juniper that is acceptable on rangeland depends on livestock use, wildlife cover, endangered species regulations, topography, and watershed management. Removing large junipers provides water, sunlight and nutrients for seedling junipers. Seedling densities can be quite high within just 3 years after mature trees are removed. Therefore, it is important to plan follow-up practices before implementing any treatment. A number of approaches and tools are available for juniper management. Several of them may be required to reach a sustainable situation. It is important to remember that junipers are most vulnerable as seedlings or saplings, and this is also the life stage that is most economical to manage.

Mechanical Methods

Chaining, tree dozing or grubbing, bulldozing, and root plowing are mechanical methods of tree removal.These methods are typically used on a large scale and usually on large trees.The roller-ball chain is a new technology that reduces horsepower requirements for chaining juniper by up to 80 percent.

Hydraulic shears are another recent innovation. This method is effective on ashe juniper trees because they do not resprout.

Hand grubbing and hand cutting are effective juniper removal methods. Seedlings and saplings up to 28 inches tall can be hand grubbed easily and economically when soils are moist and not too rocky. Follow-up treatments will be needed every 6 to 8 years, and must be applied before junipers reach reproductive maturity to reduce seed production.

Chemical Methods

Broadcast herbicide treatments are not available for juniper management. However, it is feasible to treat individual plants with herbicides if plant density is low (up to about 300 plants per acre) and plants are no taller than 3 feet.Two approaches for individual plant treatment are available (see L-5160,"Brush Busters: How to Master Cedar," Texas AgriLife Extension Service). One method is to apply an undiluted herbicide, hexazinone liquid or pellets, to the ground near the stems of trees to be controlled. Because this herbicide is nonspecific for juniper, you must be careful to keep it away from desirable tree species. The second method is a leaf-spray containing 1% picloram. Plant size is critical when using the leaf-spray, as cost doubles with each foot of increase in seedling or sapling height.

Fire

Prescribed burning is an effective tool for juniper management. It is most effective in controlling initial juniper invasions and as a followup practice. One system that has been effective is to use roller chopping or 2-way chaining on ashe juniper to stimulate grass production, and follow that with a prescribed burn.

Properly timed fires extend the effectiveness of expensive mechanical treatments.The first follow-up burn probably should be used 3 to 5 years following a treatment such as chaining, tree dozing, or roller chopping. Subsequent burns usually can be conducted on an 8- to 10-year cycle. Burning cycles on lowland sites with deep soils will be shorter because growth rates are faster.

Ashe juniper should be burned when it is less than 4 feet tall. Redberry should be burned before the bud zone becomes covered by soil at 8 to 12 years of age.This corresponds to an upland tree height of 18 to 24 inches. Trees on deep soils may be 25 to 37 inches tall at this age.

Fine fuel loads are important for successful prescribed burns.A minimum of 2,000 pounds per acre of dry grass is needed in bunchgrasses such as little bluestem. Burns can be successful with as little as 1,000 pounds per acre of sodgrasses such as buffalograss or common curley mesquite.

With adequate fuel loads, expected plant kill is high. For ashe juniper less than 4 feet tall, control should be nearly complete.About 70 percent of redberry juniper with bud zones not yet covered by soil have been killed by fires.

Prescribed burning increases the potential for soil erosion for 9 to 15 months on moderate slopes and for 15 to 30 months on steep slopes. Grazing must be deferred before a burn to build the fuel load, and afterward to prevent the overuse of palatable grasses.

Biological Control

Currently, the only biological control for juniper is the use of goats. About 50 percent of a goat's diet is browse. Goat winter diets generally contain about 10 percent juniper, but may be as high as 20 to 30 percent in some years. Winter is the most likely time for goats to eat juniper, because it is frequently the only green forage available. Spanish goats eat more juniper than Angoras. Recent research indicates that Ibex goats may eat even more juniper than Spanish goats.

Goats generally prefer the scale-leaf stage over the earlier needle-leaf stage, even though volatile oil concentrations are higher in the older leaves. However, until the cotyledons (seed leaves) drop off at about 3 to 4 months, goats prefer the needle-leaf stage. Perhaps the sharp tips of leaves in the needle-leaf stage also protect the young junipers.

The volatile oil content limits the amount of juniper goats consume. Feeding a high quality protein supplement appears to increase juniper consumption. One study showed that without supplementation, maximum juniper intake for an 80-pound goat was less than 0.6 pounds per day.With an alfalfa or cottonseed meal supplement, maximum juniper intake increased to about 0.8 pounds per day. However, with a corn supplement, juniper intake was only about 0.5 pounds per day. It appears that protein helps the liver detoxify volatile oils. With an 80-pound goat and a 0.8-pound juniper intake rate, it would take about 12 days to eat all the leaves on a 3-foot tree with 10 pounds of foliage. In contrast, juniper seedlings less than 12 inches tall have only a few ounces of foliage. This same goat might be able to eat 50 or 60 12-inch-tall junipers a day, or several hundred plants less than 6 inches tall.This point emphasizes the need to use goats on smaller junipers. The most effective time to use goats to remove redberry junipers may be soon after seedlings emerge in fall to early spring when there is above average precipitation. For goating to be effective with redberry juniper, the bud zone must be removed, which means removing the plant to ground level. Simulated browsing studies with seedlings mostly in the needle-leaf stage showed that 82 percent of plants were killed by removal to ground level, 52 percent by removal to 0.4 inches above ground, and only 15 percent by removal of half the foliage.

Biological control with goats can affect desirable browse plants and, therefore, wildlife. Goats may eat juniper at anytime of year, but because juniper consumption is limited by the volatile oil content, goats may overuse desirable browse plants. One approach to this problem is to stock goats lightly on a year-long basis and then concentrate high densities of goats (five to eight per acre) for short periods of time on areas suitable and targeted for biological control. This intense goating should be done in the winter when most desirable browse is dormant, and probably for no longer than 30 days. Goats will eat more juniper if fed a high protein supplement such as cottonseed meal or a feed with 20 percent or greater crude protein.

Grazing Considerations

Much of the increase in junipers and other woody plants observed since European settlement is caused by the reduction in naturally occurring wildfires. Recent research indicates that grazing does not necessarily cause woody plants to increase by reducing competition from grasses. In some areas where grazing has been excluded for long periods woody plant densities have increased dramatically.

Computer models that estimate the outcome of different grazing intensities and fire frequencies on woody plants in the Edwards Plateau predict that, without fire, open grasslands would be converted to dense woodlands within 70 years, regardless of grazing management. Without grazing, cool-season fires every 20 years could maintain fairly open grasslands, but a fire frequency of 25 years or more resulted in a closed woodland.

With heavy continuous grazing, even a 10-year cool-season fire interval appears unable to maintain an open grassland because grazing removes fuel and lowers fire intensity. Even with moderate grazing and no rest, a 10-year interval appears to maintain an open grassland only rarely, and then much depends on weather. It appears that a 1-year pre-burn rest from grazing is necessary to maintain a grassland.

The main effect of heavy grazing appears to be a decrease in the amount of taller, more productive midgrasses in favor of less productive shortgrasses. These shortgrasses create a less uniform fuel load and are less able to sustain intense fires.

Conclusions

Native juniper infestation is increasing in Texas. Although junipers are beneficial to wildlife and prevent erosion on steep slopes, they can cause problems in the environment if not managed. For example, these plants can prevent 40 percent of annual rainfall from reaching the soil where it can recharge streams and aquifers. Forage plants needed by wildlife and livestock have difficulty competing with junipers for water, soil nutrients and sunlight. Management options include mechanical, chemical, fire and biological methods. Keys to juniper management are: 1) establishing a follow-up plan that includes as many management options as possible; and 2) concentrating control efforts on seedlings or saplings, the most vulnerable stage and the least costly to control.

For more information

Some of the information in this publication was adapted from the following sources:

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Information on the volatile oils in junipers comes from unpublished data supplied by Owens and Launchbaugh.

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