

# Angora Goats for Conversion of Arizona Chaparral: Early Results<sup>1</sup>

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This study is part of the Rocky Mountain Forest and Range Experiment Station program researching methods of effective, economical, and environmentally safe methods of converting chaparral to brush-grass mosaics.

Research over the last quarter century has shown that conversion of Arizona chaparral to grass significantly increases water and forage yields, reduces fire hazard, and may increase wildlife values (Hibbert et al. 1974).

Total rainfall and its distribution throughout the range of Arizona chaparral is adequate for establishment of seeded grasses. Precipitation ranges from 16 to 30 inches annually, with about 55 percent falling primarily from November through April and the remaining 45 percent from May through October (mostly during the growing season from July through September). However, to date, the only entirely effective and environmentally acceptable means of controlling shrubs and promoting grass establishment is the root plow. Its use is limited to less than 8 percent of the chaparral acreage because of rugged topography and the rocky character of soils. Fire is effective for opening up mature stands, but the only important shrub species killed are manzanita (*Arctostaphylos pringleii* and *A. pungens*) and desert ceanothus (*Ceanothus greggii*), and germination of their seeds is stimulated by fire. The

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<sup>3</sup> The herbicides discussed in this report have been used experimentally; their use does not imply that they are recommended or registered for watershed use. The use of any herbicide for project or commercial purposes must conform with regulations of the Environmental Protection Agency and be registered for the intended use.

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Abstract: Use of goats to convert chaparral to brush-grass to increase water and forage may be an alternative to chemical and mechanical means. Results indicate that trampling of grass seed by goats in burned-over chaparral promotes germination and establishment. Because shrubs constitute a large percentage of the goats' diet, sprouting is retarded. Goats prefer about the same shrub species as other domestic livestock and big game herbivores. Since goats relish young grasses, areas must be protected during grass establishment.

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major dominants, shrub live oak (*Quercus turbinella*) and mountain mahogany (*Cercocarpus betuloides* and *C. breviflorus*), sprout vigorously and regain dominance before herbaceous plants can become established. Foliage spray herbicides<sup>3</sup> of the phenoxy group, such as 2,4-D, 2,4,5-T, and silvex and mixtures thereof, have been used, but they do not provide adequate control without several successive annual applications. Soil-applied herbicides previously tested, such as fenuron, picloram, and karbutilate, are potent brush killers but, being nonselective, they are also toxic to, and may delay establishment of, herbaceous plants. Even when shrubs are controlled by herbicides, grass establishment requires several years because it is not possible to plant the seeds. The terrain is too rugged and rocky for use of conventional seedbed preparation and seed planting equipment. Thus, conversion by techniques presently in use leaves much to be desired.

In view of the foregoing, and since public concern about environmental quality has become a powerful force in resource management, we need more efficient, economical, and environmentally safe methods for conversion of chaparral.

Following prescribed burning and seeding, browsing with goats to trample seeded grasses into the soil and to retard recovery rate of the sprouting shrubs might be an effective tool for use in chaparral conversion. If goat use will hold the shrubs in check until a grass cover that will carry fire becomes established, the conversion can be maintained by periodic prescribed burning, or possibly by continued goat browsing.

The objective of this study is to determine if prescribed burning, seeding, and goat browsing in the fall can be a useful tool for conversion of Arizona chaparral.

## PRIOR RESEARCH

Goats are primarily browsers and, given a choice, prefer woody species, as studies in East Africa (Wilson 1957), Texas (Fraps and Cory 1940, McMahan 1964), and Australia (Wilson et al. 1975; Wilson, Mulham, and Leigh 1976) have shown. In Mexico, Carrera (1971) observed 1,728 goat bites and found 83 percent browse and forbs and 17

percent grass bites. Huss et al. (1970) and Zertuche (1970) noted that goats preferred browse even when there was an abundance of grass. Wilson, Mulham, and Leigh (1976) found that goats show a definite preference for certain shrubs and tree leaves over others.

"Goats eat a wider range of available vegetation than do sheep and should make better use of the vegetation as a whole. At the same time the quality of their diet is equivalent to that of sheep so that the greater production from the land should be obtained from goats than sheep. It is clear that the effect of goats on the woody species in a community will be dependent on the acceptability to goats of the particular species present. Some will be controlled and, depending on species composition, possibly eliminated while others may be relatively untouched and become more dominant" (Wilson et al. 1975).

Fraps and Cory (1940) found that cattle fed on the smallest numbers of different kinds of plants, sheep on a somewhat larger variety, while the diet of goats was quite diversified.

Davis, Bartel, and Cook (1975) used goats to control Gambel oak (*Quercus gambelii*) sprouts in Colorado and observed that "the goat diet was usually composed of over 85 percent oak leaves, about 10 percent forbs, and 5 percent grasses" (no values regarding relative species composition were given). However, another research study indicated that goats consumed large portions of grass and forbs and that Spanish goats consumed significantly less grass and more browse than angora goats (Taylor 1975).

Because many food habit studies failed to determine relative forage availability, it is not possible to state with certainty whether a particular class of forage was used because of preference or because little or no other kinds were available. Malechek and Leinweber (1972) measured botanical composition of angora goats' diets and the forage available for consumption; they found that grass was the major class of forage consumed during the growing season (June to mid-October). The proportion of browse in diets increased rapidly in late October and November, and remained relatively high through May (greatest use of browse was from mid-March to mid-April). Although Malechek and Leinweber (1972) did not say this, it is likely that the peak in browse use corresponded with the period of initiation of shrub shoot growth and the period prior to initiation of grass growth.

Du Toit (1972) investigated the role of goats in controlling sprout regrowth after sprouting had begun, following chopping of shrubs in a brush-grass community (no data was presented on composition of the stand). The time goats spent browsing shrubs was about equal to the time they spent grazing grass. Basal cover of grass increased significantly in the 3-year period, and shrub regrowth was negligible. Cattle-carrying capacity was greater than in similar areas grazed

by sheep, where shrub regrowth was double that in the goat use pastures.

In a study within the Edwards Plateau region of Texas, Bryant et al. (1979) found that goat diets were nearly equal in percent grass and browse consumed.

#### STUDY AREA

The study area is a 210-acre enclosure (roughly 3,000 square feet) located on the Tonto National Forest, 10 miles northeast of the town of Payson, Arizona. This area was selected because of accessibility, the presence of permanent water, and the dominance of a mature stand of shrub live oak-mountain mahogany--the most widespread and dominant associate of the Arizona chaparral (Knipe et al. 1979). Other important shrub species common to the type are also represented, such as manzanita, desert ceanothus, yellowleaf and Wright silktassel (*Garrya flavescens* and *G. wrightii*), skunkbush (*Rhus trilobata*), sugar sumac (*R. ovata*), hollyleaf buckthorn (*Rhamnus crocea*), and cliffrose (*Cowania mexicana*). Average annual precipitation at Payson (elevation 5,000 feet) is 21 inches; the study area is 300 to 800 feet higher so it is likely that annual precipitation is about 23 inches.

Elevation gradually rises from 5,300 feet at an east west channel near the southern boundary to 5,800 feet at the crest of Diamond Rim at the north boundary (fig. 1). There is a north slope comprising about 20 acres (10 percent of the area) south of the main channel, and about 190 acres (southerly exposure) above and north of the channel. This area is dissected north to south

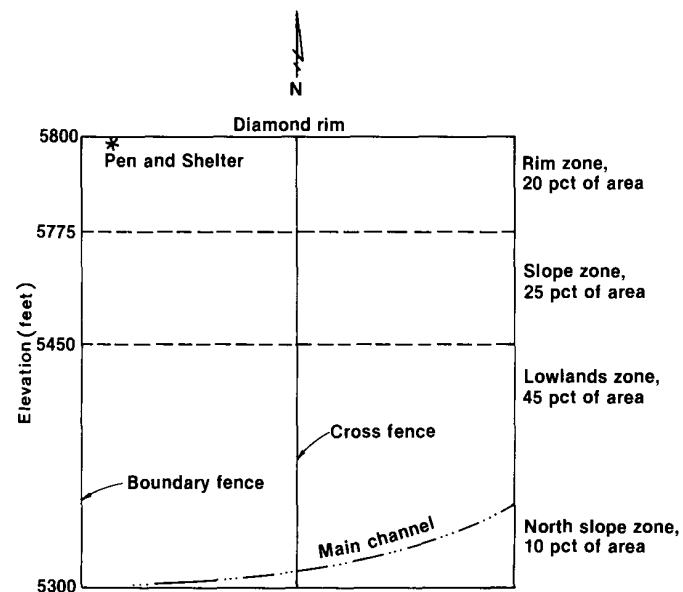


Figure 1--Schematic description of study area (not to scale).

by several branch channels which flow into the main east-west channel. The 20-acre north slope is shrub live oak-mountain mahogany, with sparse Wright silktassel. Mountain mahogany dominates the higher elevation (rim zone), but sparse shrub live oak and Wright silktassel are also present. This zone comprises about 20 percent of the total acreage.

Elevation decreases rapidly from the rim through an intermediate elevation zone of shrub live oak-mountain mahogany with sparse Wright silktassel, sugar sumac, and skunkbush. This intermediate zone comprises about 25 percent of the area.

Between the base of the rim slope and the channel is a lowland zone, ranging in elevation from 5,300 feet at the main channel to 5,450 feet at the base of the rim slope. This zone is shrub live oak-mountain-mahogany; manzanita is codominant in a few small pockets, and Wright silktassel, sugar sumac, and skunkbush are sparsely scattered throughout. The main channel is occupied by pine (Pinus ponderosa), Emory oak (Quercus emoryi), and walnut (Juglans major), with a sparse mixed shrub understory.

#### PROCEDURES

Starting from a random sample point, four permanent sample lines were established at 600-foot intervals across the area (upslope to downslope). Cover percentages (total and by individual shrub species) were determined by 100-foot intercept segments along these lines in September 1979 and again in 1980. Percent of individual species utilized was determined along the intercept lines at regular intervals for several weeks after introduction of the goats by:

1. Selecting a random number between 1 and 100 for each 100-foot segment of each line.
2. Beginning at the random point, tallying the first 10 plants of each species as browsed or not browsed.

The height of the tallest sprout of each plant sampled for utilization was also noted.

At the end of the growing season (Sept. 30, 1980), the percent biomass removed by goat browsing was estimated visually. The area had been burned the first week of October 1979, which was a departure from the norm since controlled burning in the Arizona chaparral had always before been conducted in the spring. The area was burned in the fall this time because

1. Winter rains are cyclonic in nature (low intensity, long duration) and are less apt to result in erosion of the freshly bared soil than would convectional summer storms which are of short duration and high intensity. Summer rains typically result in 1-1/2 inches precipitation in 15 minutes.

2. Burning of chaparral imparts a hydrophobic property to the soil which restricts infiltration. This property may be less detrimental in the winter because the precipitation is less intense, and trampling by goats, chemical, microbial, and root activity, leaching, and freezing and thawing prior to the start of the summer rains may dissipate the hydrophobic layer.

The burn eliminated top growth over 80 percent of the area, leaving 20 percent in a mosaic pattern for wildlife cover and esthetic purposes. The main channel is dotted with large ponderosa pine, Arizona walnut, junipers (Juniperus monosperma, J. deppeana, J. osteosperma, J. scopulorum) and Emory oak trees which were retained for wildlife habitat.

The area was broadcast seeded with weeping lovegrass (Eragrostis curvula) in the fall immediately after burning, at a rate of 1 pound pure live seed per acre.

The area was fenced with a seven-wire electric fence which uses smooth, 12-1/2 gauge wire, and fiberglass posts. The fence is operated by a 12-volt wet cell battery (charged by a solar cell) attached to a high-powered low-impedance energizer which pulsates a 5,000-volt current 60 times per minute; each pulse lasts 3/10,000ths of a second. The fence is designed not only to keep livestock in but to keep predators out. Wires are spaced close together near the ground and increasingly further apart toward the top. The height of the fence was limited to 54 inches so that deer and elk movement into the area was not restricted. A 200-foot strip was left outside the grazed area for measuring shrub recovery without grazing.

In an attempt to preclude overuse and because of problems that would be present if numbers had to be reduced, approximately one goat unit per acre was decided upon as the stocking rate. In June, 242 angora wethers<sup>4</sup> were introduced into the area. Wethers are being used for three reasons. First, kidding is a highly specialized operation; second, wethers are larger than nannies and less susceptible to predation; and third, if wethers were to escape, they would be unable to establish a self-perpetuating feral population.

The plan was to burn, seed, and, when the shrubs had started to sprout, introduce goats to trample the grass seed into the soil and suppress shrub growth through browsing. It was anticipated that the young, tender, and presumably palatable shrub sprouts would be preferred over establishing grasses. Three weeks after their

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<sup>4</sup>Of the 242 wethers, 42 were 3 years of age and equal to 1 goat unit each, 100 were 2-year olds considered 0.90 goat units each, and 100 were yearlings considered 0.75 goat units each, so that the area was stocked with 217 goat units.

introduction, when grasses were beginning to grow, the goats were eating or pulling up a high percentage of grass seedlings. The area was immediately divided into two 105-acre pastures and the goats were kept in one pasture until the end of the growing season. Thus, this pasture was used from June 11 to November 1, 1980. Except for the period from June 11 to July 1, the other pasture was deferred during the 1980 summer growing season.

A fair stand of grass resulted in the summer-deferred pasture; at the end of the growing season (about November 1, 1980), after the grasses had matured and set seed, the goats were moved to this pasture. This summer-deferred pasture will be grazed until about June, at which time the summer 1980 grazed pasture will be seeded and the goats put in it long enough to trample the seeds into the soil. When the summer rains start, the herd will be removed from the experimental area for the duration of the 1981 growing season.

## RESULTS AND DISCUSSION

### Shrub Response

The heaviest used shrubs during the first 16 days after introduction of the goats were shrub live oak, sugar sumac, and skunkbush (table 1). Heavy use of the palatable skunkbush was expected, but it was also expected that the goats would take mountain mahogany and Wright silktassel more readily than shrub live oak and sugar sumac.

During the first 3 weeks of use, the values were estimated, with the exception of sugar sumac, to also be representative of percent biomass removed. A high percentage of the plants of this species were browsed, but only the tips of the sprouts were taken so that very little biomass was removed (table 1). The use pattern had changed by the fourth week after introduction of the goats; by this time the use of mountain mahogany had increased and was being heavily used both with respect to percentage of plants and biomass removed. Heavy use of the relatively palatable Wright silktassel did not occur until about 2 months after introduction of the goats. Thereafter, use of this species was about equal to that of mountain mahogany. The reasons for the relatively heavy use of shrub live oak and light use of mountain mahogany and silktassel during the first few weeks may be these:

1. Mountain mahogany and Wright silktassel do not grow in Texas and they were new to the goats.
2. Mountain mahogany and Wright silktassel growth had started earlier in 1980 than shrub live oak, and they may have been somewhat coarser by June when the goats were introduced.
3. During the first 3 weeks after introduction, the goats concentrated in and grazed a strip about 100 yards wide across the area along the base of the rim (fig. 1). Vegetation within this zone is predominantly shrub live oak.

Number 3 above is probably the best explanation although number 2 may also have some merit.

Table 1--Percent of important plant species browsed (Summer 1980)

Date	Species										
	Shrubs					Forbs		Half shrubs		Grass <sup>1</sup>	Tree
	Shrub live oak	Mtn.-mahog.	Wright silktassel	Sugar sumac	Skunkbush	Lambs-quarter.	Morning glory	Snake-weed	Rough menodora		Juni-per
6/1/80 <sup>2</sup>	0	12	14	0	0	45	41	0	0	25	0
6/11/80	Goats introduced										
6/19/80	29	18	16	T	13	70	80	0	0	50	10
6/27/80	82	55	26	75	83	100	90	0	0	85	10
7/8/80	93	89	59	98	100	100	100	20	0	93	23
7/23/80	95	93	60	99	100	100	100	68	10	98	38
8/8/80	100	100	90	100	100	100	100	90	15	100	62
8/20/80	100	100	100	100	100	100	100	92	20	100	73
9/30/80	100	100	100	100	100	100	100	100	30	100	100
Percent biomass <sup>3</sup> reduction	60	80	75	10	80	95	90	40	20	95	15

<sup>1</sup>Primarily weeping lovegrass with traces of native sideoats grama (*Bouteloua curtipendula*), red threeawn (*Aristida longiseta*), and squirreltail (*Sitanion hystrix*).

<sup>2</sup>Prior to introduction of goats; deer and elk use.

<sup>3</sup>Visually estimated on 9/30/80.

Species preferences described above, for the pasture used during the summer, appeared to be the same when the goats were turned into the summer-deferred pasture in November, the only exceptions being that the dry grass and forbs were not used as heavily as during the growing season.

The palatable forbs--lambsquarter (Chenopodium album) and morning glory (Ipomea hirsutula)--and grass were all heavily used during the growing season.

Of the two important half shrubs in the area, snakeweed (Xanthocaphalum sarathrae) and rough menodora (Menodora scabra), snakeweed received the heaviest, though only moderate, use. The relatively light use of rough menodora is surprising as this species is relished by deer, elk, and cattle; it was anticipated that it would be highly palatable to goats.

Juniper was taken readily by the goats, but actual removal of foliage is light (table 1) because most is out of reach of the animals.

Percent reduction in height of the three most important shrub species (shrub live oak, mountain-mahogany, and Wright silktassel) as a result of goat browsing varied appreciably (table 2). These measurements, the percent browsed plants by species discussed above, and the estimates of biomass removal indicate a strong preference for mountain mahogany and Wright silktassel over shrub live oak. Heavy use of Wright silktassel did not begin until late in the summer; after October it appeared that use of the species was about equal to that of mountain mahogany.

#### Other Observations

Because of restrictions imposed by topography and accessibility, the holding pen and shelter were placed in one corner of the area (fig. 1). It was believed that the herd should be penned nightly as a precaution against predation losses, so the goats were salted in the pen and shelter area to induce them into the pen at night.

(Because of topography and labor limitations, it would not have been possible to herd the goats to the pen daily.) This resulted in an undesirable use pattern; a quarter circle area extending about 400 feet out from the penning area became a heavily used "sacrifice zone"; the problem was magnified because the vegetation composition within the zone was predominantly mountain mahogany (fig. 1), which is more palatable than the other major dominant (shrub live oak). This "sacrifice zone" could have been reduced or possibly prevented had it been possible to centrally locate the pen-shelter site and salt the goats in outlying areas. It appears that the electric fence is effective against predation (no losses have occurred), and it may not be necessary to pen the herd nightly.

Treatment (prescribed burning and goat browsing) resulted in decreased shrub cover, increased herbaceous cover, and an apparent reduction in fire hazard and improvement in water yield (table 3).

There was a fair stand of grass over the entire study area by the end of the second week in July. Some of the seedlings were from spring emergence and some were from late June and early July rains. Precipitation in the area totaled 8 inches during the growing season (May through September)--about 7 inches fell from June 20 through September. Almost 16 inches fell during the 1980-81 winter months (October through April). Grass production increased in the summer-deferred pasture--the stand was better than is characteristic of seedlings in the Arizona chaparral following burning. It is believed that this is due, in part, to "seed planting" as a result of trampling by the goats during the 3 weeks before the herd was excluded from this pasture. It remains to be seen if goat browsing during the winter months will result in sufficient control of shrubs to maintain and/or increase the grass stand. This will depend on the degree of shrub cover reduction from browsing pressure prior to initiation of spring growth, at which time utilization of grasses may necessitate removal of the herd from the pasture.

Table 2--Average height (feet) of important shrubs as related to browsing.

Date	Species								
	Shrub live oak			Mountain-mahogany			Wright silktassel		
	Browsed	Not browsed	Pct. reduction	Browsed	Not browsed	Pct. reduction	Browsed	Not browsed	Pct. reduction
6/11/80 <sup>1</sup>	1.70	1.68		0.92	0.93		1.34	1.36	
7/23/80	1.47	--		0.89	--		1.60	--	
9/11/80	1.59	--		0.74	--		1.43	--	
11/1/80	1.56	2.17	28	0.49	1.50	67	1.17	2.10	44

<sup>1</sup>Prior to introduction of goats.

Table 3--Characteristics of the study area, October 1979 to November 1980.

	Pretreatment	End of first growing season	
		Summer-grazed pasture	Summer-deferred pasture
Shrub cover (pct.)	70	10	28
Estimated grass production (no./acre)	25	0	200
Water production	Intermittent	Continuous	No summer or fall flow
Fire hazard	High	None	None
Wildlife	?	Heavy deer and elk use	Very heavy deer and elk use
	No quail	4 coveys quail	2 coveys quail
	No cottontail	Sparse cottontail	Cottontail numerous

CONCLUSIONS

Conversion of chaparral by goat browsing will require some form of put-and-take system of grazing management to protect the area during the critical period of grass establishment. Results to date indicate that it may be possible to control shrub cover sufficiently to result in increased water yield. Whether or not this can be accomplished while establishing an acceptable grass cover remains to be seen. It appears that trampling does effectively "plant the seed" and enhance seedling establishment.

Goats utilized a far wider range of vegetation in the Arizona chaparral than other domestic livestock and resident big game. Species such as snakeweed, juniper, and sugar sumac appear to be used more heavily by goats than by other animals common to the area. Chaparral species most preferred by goats are comparable to those of other domestic livestock and resident big game. Thus, goat browsing in the Arizona chaparral can be expected to result in heaviest use of species also preferred by cattle, deer, and elk.

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