Forestry and Agriculture at the Crossroads in the Management of Piñon-Juniper Woodlands[1]

John Mexal, Professor
Agronomy and Horticulture, NMSU*

with
James T. Fisher, Professor of Agronomy and Horticulture, NMSU
and
Rex D. Pieper, Animal and Range Sciences, NMSU

ABSTRACT

Piñon-juniper woodlands occupy more than four million ha or 14% of the land base in New Mexico. The majority of land (42%) is managed by the federal government. The remainder is either privately (29%), Indian, (18%) or state owned (12%). Approximately 62% of the piñon-juniper woodland is considered accessible and suitable for forestry and agriculture use. The current annual production of the woodland is about $29 and ornamental products is more than $3,600/ha/yr or more than $8 billion/yr. Clearly, the potential value is unattainable. However, a reasonable target of $60 million/yr is achievable through better management and utilization.

All piñon-juniper land units do not have the same production capacity, and they are not equally accessible for product harvest. Furthermore, market demands for specific products such as fuelwood or ornamentals, vary among regions. Consequently, the actual value of all plant products obtained from New Mexico's piñon-juniper woodlands is well below potential. However, the value could be increased substantially if more productive woodlands were intensively managed.

At present, land managers generally do not have enough information to optimize benefits from more than one product. An absence of critical knowledge in some cases permits over-exploitation of a product. Future use depends on interdisciplinary teams developing technology to manage this valuable, diverse resource better.

INTRODUCTION

The piñon-juniper woodlands represent a valuable and diverse resource in the southwestern United States. There are about 17 million ha in the western United States with more than 90% in Arizona, Colorado, Utah, Nevada, and New Mexico (Fig. 1). New Mexico has about 25% of the piñon-juniper woodlands, or about 4.2 million ha. The management strategy for these lands has changed tremendously over the years, from clear cutting the woodlands for lumber or charcoal, to clearing for rangeland, to custodial. Land managers realize this land is capable of sustainable yields of a multitude of products; however, the arid environment of the piñon-juniper woodlands dictates careful management to preserve the resource. The objective of this paper is to review the importance of the piñon-juniper woodlands in New Mexico and to discuss the management for sustained yield of the varied products.

ECOLOGY

The piñon-juniper woodlands occur throughout NM at elevations between 1370-2400 m. Annual precipitation ranges from 250 to 500 mm. The minimum mean monthly temperature is as low as 25°C and the maximum mean is 35°C. The average frost-free period is 120 d (range = 90-205 d). Soils tend to be shallow, rocky, infertile, and well-drained. The sites are xeric and evapotran-

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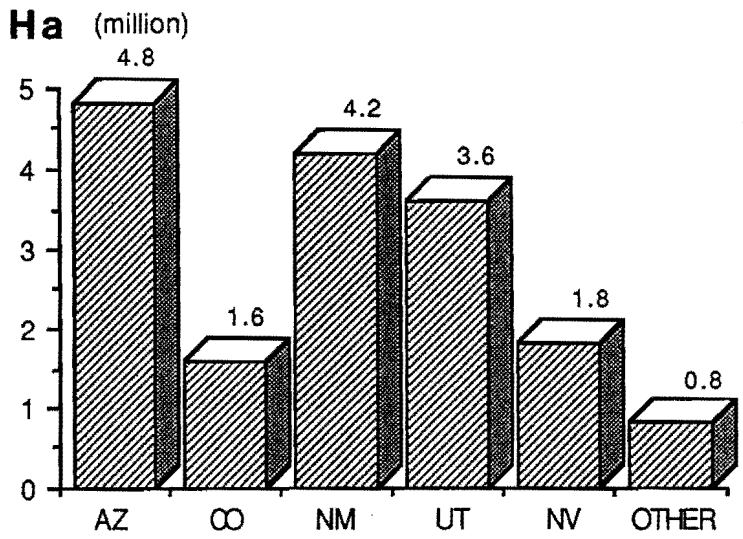

Fig. 1. Piñon-juniper forest distribution in the western states (USDA 1982).

spiration exceeds precipitation in seven of twelve months. Most precipitation (50%) occurs during July through September (Lane and Barnes, 1987). Despite the shallow soils, measurable runoff occurs only during the months July through October (Fig. 2).

In New Mexico, the pifion-juniper woodlands consist primarily of *P. edulis, J. monosperma,* or *J. deppeana.* Understory vegetation consists of shrubs such as *Artemesia tridentata, Arctostaphylos, pungens, Quercus gambelii, Rhus trilobata,* and *Opuntia* spp. Important grass genera include *Bouteloya, Poa, Oryzopsis,* and *Agropyron* (Pieper and Lymbery, 1977; Ronco, 1987). The relative cover of pifion and juniper is a function of elevation (Tueller et al., 1979; Woodin and Lindsey, 1954) with juniper dominating a low elevations (Fig. 3A). Above 2100 m the cover is equally split between pifion and juniper, and pifion dominates about 2100 m. This is analogous to woodlands in Nevada, except the junction occurs at about 1900 m there (Fig. 3B).

The pifion-juniper woodlands are managed by several entities in New Mexico (Table 1). The largest land base (1.678 million ha) is federally managed (USFS and BLM) and amounts to 42% of the total woodlands (Fowler and Oliver, 1988). The BLM-managed land is 90% accessible, while USFS land is only 65% accessible. Steeper slopes on USFS land account for the lower accessibility. Private landowners manage 1.167 million ha, of which 74% is considered accessible to management. The state owns 470,000 ha with 71% accessible. The Indian tribes own 722,000 ha, which are not accessible by the general public; however they are subject to management practices by the individual tribes.

Table 1. Ownership pattern of piñon-juniper woodlands in New Mexico (Fowler and Oliver, 1988)

	Pifion-juniper Woodlands (million ha)	% of Total	Accessible (%)
Private 1.16	29	74	
USFS	0.912	23	65
BLM 0.766	19	90	
Indian	0.722	18	
State 0.470	12	71	
Total	4.037	100	62

PRODUCTIVITY

Folliott and Clary (1986) estimated the standing volume of pifion-juniper in the West at more than 1.4 billion m^3 annually. New Mexico, with 25% of the pifion-juniper landbase, could have as much as 25% of the volume. The energy equivalent of the annual production in New Mexico alone could be as high as 70 trillion BTUs. This is equivalent to 11 million barrels of oil, valued at about $209 million/yr at $19/barrel.

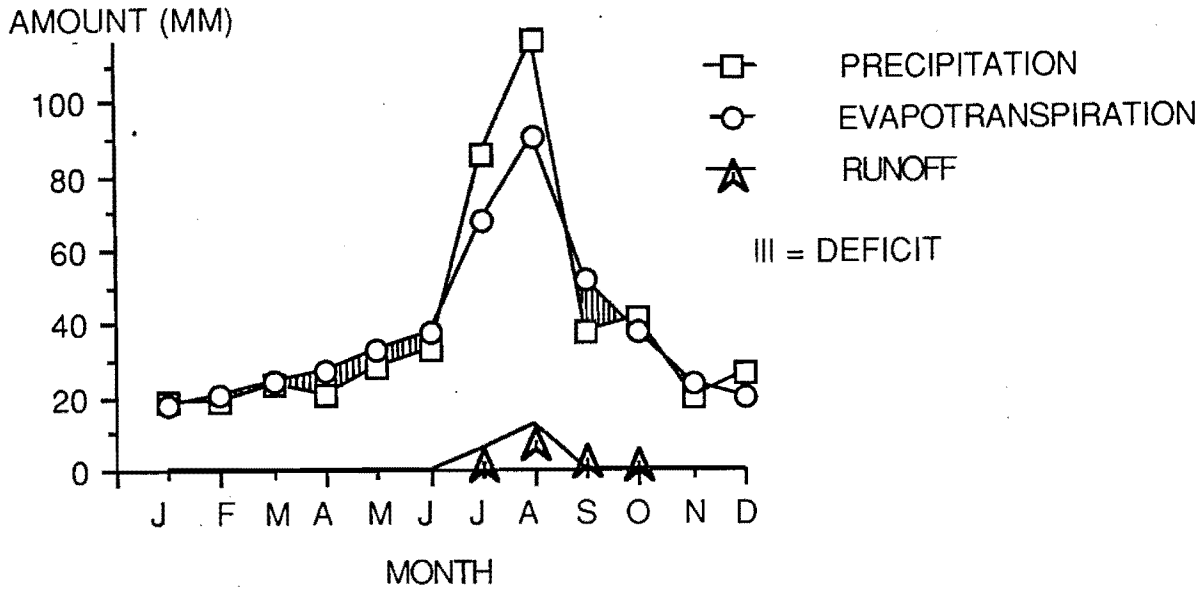

Fig. 2. Observed precipitation and estimated evapotranspiration and runoff for a site near Los Alamos, NM (after Lane and Barnes, 1987).

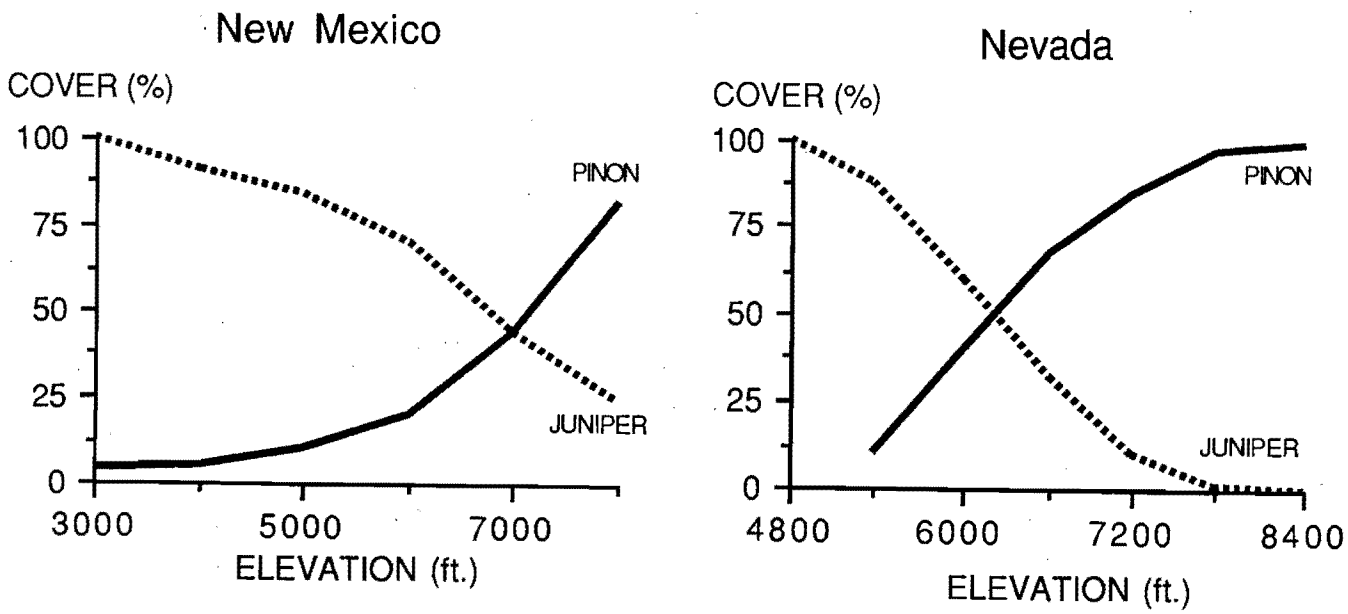

Fig. 3. Cover of piñon and juniper in relation to elevation in New Mexico (Woodin and Lindsey, 1954) and Nevada (Tueller et al., 1979).

The piñon-juniper woodlands are more than just a source of energy; they yield a variety of products important to New Mexico. They provide forage for wildlife and cattle, fuelwood and fence posts, nuts, and ornamental and Christmas trees. However, piñon-juniper woodlands are considered primarily a forage-producing ecosystem.

Forage production on unimproved woodlands is 20–400 kg/ha/yr (Clary, 1987). Following total tree removal, forage production increases to 423–741 kg/ha/yr. Although forage production is often considered the primary product, piñon-juniper woodlands are also an important source of wood products. Mean annual increment is 0.7–3.5 m^3/ha/yr (Ronco, 1987). In New Mexico, yields of more than 100 m^3/ha have been recorded (Fowler et al., 1984). The major use for the wood product is fuel, but fenceposts are also harvested.

Specialty crops are also important sources of income in certain regions. Piñon nuts are a valuable resource in western New Mexico where more than 500,000 kg are collected each year. Yield is 78-280 kg/ha, with a crop produced every 3–7 years. Another important source of income is small trees cut for Christmas trees or dug for landscape plantings. For example, in 1980 twelve thousand permits were issued to dig live piñon (Fowler et al., 1985). The estimated value of these trees was more than $700,000.

Piñon-juniper woodlands also provide habitat for wildlife and are an important recreation resource. The value of the recreation and hunting is estimated at more than $40 million/yr (Howard, 1988). The piñon-juniper woodlands are also important watersheds. However, this is the one parameter that is not easily ameliorated, and water is the one commodity that cannot be increased appreciably through management (Clary et al., 1974). However, water quality can be degraded by poor management.

The kinds and amounts of products produced by piñon-juniper woodlands are a function of stand structure and management. More specifically, yields are determined by the interaction among site quality, tree canopy cover, and forage biomass. Many studies have demonstrated a linear or curvilinear relationship between canopy cover and forage production (Clary et al., 1974; Doughty, 1987; Everett, 1987; Short et al., 1977). Dalen and Snyder (1987) found forage production ranged from more than 1000/kg/ha for high-site index piñon-juniper lands to less than 400 kg/ha for low-site lands (Fig. 4). This productivity was for land cleared of all trees.

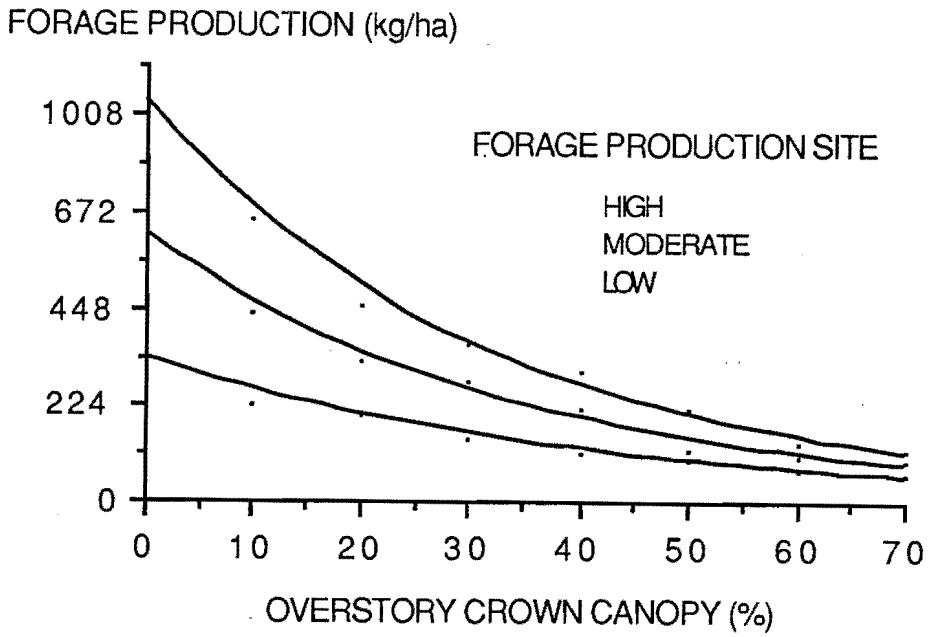

Fig. 4. Forage production as a function in piñon-juniper overstory crown canopy for three forage production sites (Dalen and Snyder, 1987).

For land with 70% crown canopy, forage production was less than 200 kg/ha, regardless of site quality. The greatest decrease in forage production occurs at overstory canopy covers of less than 20%. Forage production with 20% overstory is reduced 35-45%, compared to complete tree removal.

Forage production is a function of site quality and grazing history. Stevens (1987) examined piñon-juniper woodlands response to different grazing prescriptions over eighteen years (Fig. 5). Land protected from all grazing had the greatest cover in forbs and the least bare ground. Land grazed by rabbits, deer and cattle had the greatest shrub cover and an increase in bare ground over the eighteen years.

Although the woodlands provide many products, few studies have tried to quantify the integrated value on a sustained yield. Fowler and Oliver (1988) attempted to assess the overall value of the New Mexico woodlands. They assigned values to forage, fuelwood, fenceposts, ornamentals and Christmas trees, nuts and forage, based on a sustained, integrated resource management scheme (Table 2). The resource was valued at more than $3600/ha or $8.6 billion for the entire state. Obviously, the entire piñon-juniper woodlands of New Mexico can be managed to this potential. Some lands are inaccessible or ownership is too fragmented. Some products have only limited demand (e.g. Christmas trees), and some products such as nuts are produced sporadically. Certainly, some sites are more productive than others (cf Dalen and Snyder, 1987). More intensive management and utilization should be reserved for the most productive and accessible sites. The potential value of the piñon-juniper woodlands must be moderated by a reasonable estimate of what proportion of the resource can actually be on a sustained basis utilized (Table 2). This ranges from a high of 80% of the land base for forage production across the entire state to 0.04% for Christmas tree and live tree harvesting centered around the major population centers. Furthermore, fuelwood harvesting would likely be reduced in some areas to a sustainable level. These utilization percentages reduce the target of the piñon-juniper woodlands to $60.8 million/yr.

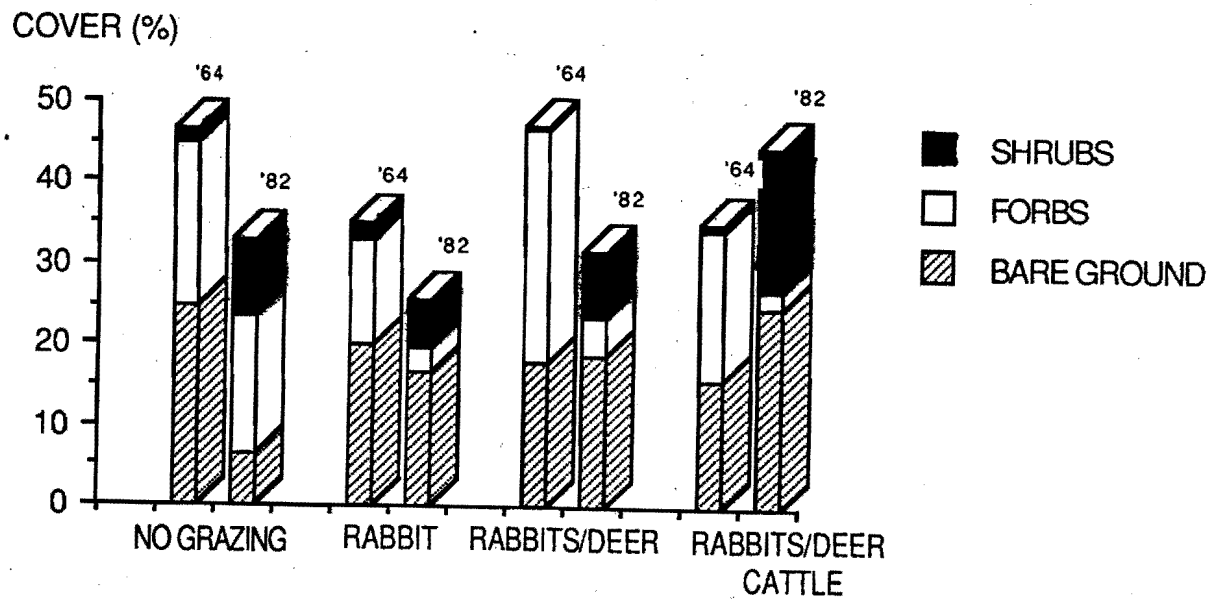

Fig. 5. Proportion of bare ground and cover of forbs and shrub under four grazing uses (Stevens, 1987).

Table 2. Potential and target value of piñon-juniper woodlands in New Mexico (after Fowler and Oliver, 1988; Howard, 1988). Potential value is derived by adjusting the value/ha by the proportion of accessible hectares. It does not include land owned by the Indian tribes.

	Potential Value		Target Utilization (%)	Target Value ($ million)
	$/ha/yr	Total ($ million)		
Fuelwood	$16.44	41.1	15	6.2
Fencepost	$6.00	15.0	15	2.2
Live Trees	$3,230	8075.0	.02	1.6
Nuts	$163.0	408.0	2.0	8.1
Forage	$7.21	18.0	75	13.5
Recreation	$16.50	41.2	50	20.6
Total	$3636.15	$8598.3		52.2

* $/ha/yr x Accessible hecteres (Does not include Indian land)

MANAGEMENT

The management the product mix obtained from piñon-juniper woodlands depends on the land management objectives of the land manager. Total conversion of woodlands to rangeland yield of several resources is gaining wider acceptance. A multiple resource management approach proposed by Fowler et al. (1985) focused on priorities dictated by legislative actions that reflect the desires/needs of constituents. Piñon-juniper woodlands should be managed for multiple use and not converted to a single resource. In integrated resource management, management of one resource is not prescribed without considering the impact this will have on one or several nontarget resources. While management of one resource may impact this will have on one or several nontarget resources. While management of one resource may impact another, management of the alternative resource may not impact the first resource in the same magnitude, or even in the same direction. A matrix management, scheme helps consider the response of nontarget commodities to management prescriptions (Table 3). A few examples can illustrate the matrix. Managing for increased runoff will have a negative impact on all other resources because total biomass removal is required to increase runoff. However, managing for other commodities will likely have little negative impact on water production, given the little runoff that occurs in New Mexico (Land and Barnes, 1987). In another case, if nut production is the primary objective, practices to increase forage such as large tree removal will decrease nut production.

	WATER	RECREATION	FORAGE	NUTS	LIVE TREES	FENCE POST	FUELWOOD
FUELWOOD	0	+/-	+/-	-	+	-	
FENCEPOSTS	0	+/-	+/-	-	+		-
LIVE TREES	0	-	+	-		-	-
NUTS	0	+	+		-	-	-
FORAGE	0	+/-		-	-	-	-
RECREATION	0		-	-	+	+	+
WATER		-	-	-	-	-	-

Table 3. Matrix depicting impact of management prescriptions on nontarget commodities.

It follows that the success of integrated resource management depends on accurate assessment of prescription impact on non-target commodities. Often, integrated resource management is no more than custodial management applied to maintain some degree of statics.

Consequently, products are harvested with little concern for sustaining yield in any area. This is illustrated in Figure 6A where the numbers represent the various types of commodities. In this case, 1 might represent traditional horticultural crops (nuts and small trees), 2 represents traditional forestry crops (fiber and posts), 3 might represent recreational activities including hunting, and 4 represents livestock production.

In most ecosystems, custodial management is impractical and often impossible. Without intervention, the ecosystem will progress to climax stage. This results in ever-decreasing income from the desired commodity. In most cases in New Mexico, this means forage production will continue to decline in the state as more lands are encroached by piñon-juniper, and as more piñon-juniper reaches maturity.

Alternative management schemes would entail managing the woody phytomass (Fig. 6B) or some combination of plant and animal biomass (Fig. 6C). Management for more than one commodity will increase net income and tend to maintain overall productivity. In fact, any number of combinations could be prescribed that would maintain or improve productivity profitability.

A systems approach to managing piñon-juniper woodlands has been promoted for at least twelve years (Anderson, 1977; Buckman and Wolters, 1987; Carder, 1977; Hurst, 1977). However, it appears to have been implemented in only a few cases, owing at least in part to the immensity of the landbase and relative low value of individual products. An alternative approach would be to designate management zones or wood baskets (Fig. 7). For example, cut and live tree production would be a relatively small wood basket centered around the major population centers of Albuquerque and Santa Fe. A fuelwood wood basket centered around the same population could be larger because of the nature of the commodities. Similar fuelwood zones could be centered around Gallup and the El Paso–Las Cruces area. For this to work, managers must be allowed to manage more than one commodity simultaneously. This approach has worked successfully in some areas (Tidwell, 1987, Wood pers. commm.). A 10,000-ha tract in Nevada generates 18,000 m^3 of fuelwood and 15,000 Christmas trees every year. In New Mexico, a land manager supervises hunting, grazing and fuelwood harvesting on private, state and federal land.

CONCLUSIONS

Custodial management is defined by Meeuwig (1984) as "where none of the other management alternatives such as type conversion for wildlife or livestock or management for sustained yield of fuelwood or other woodland products are cost effective." (Doughty, 1987). Custodial management is an appropriate management system only for remote, inaccessible stands of piñon-juniper woodlands of New Mexico. Piñon-juniper woodlands provide a variety of products and should be managed more intensely to maximize yield of a product mix suitable for the region and locale. Designating wood baskets or zones of management for particular products can improve the resource, as well as the economy.

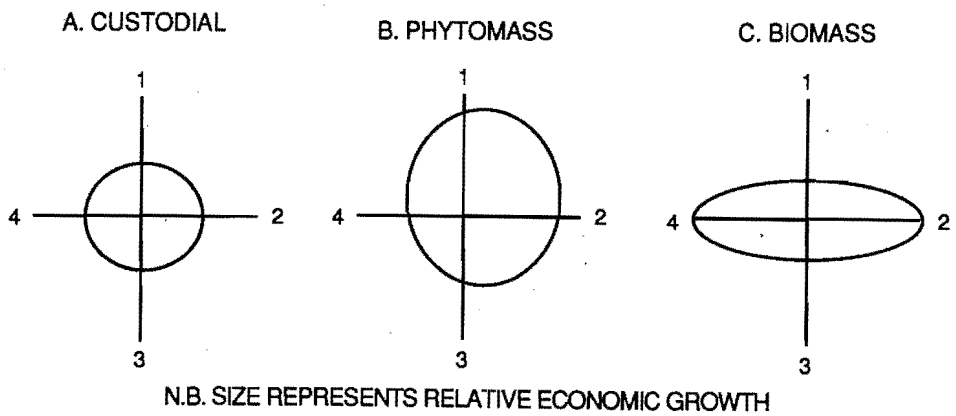

Fig. 6. Relative economic value of piñon-juniper woodlands under different resource management schemes where (1) = cut and live trees and nuts, (2) = fuelwood and fenceposts, (3) = recreation, and (4) = cattle grazing.

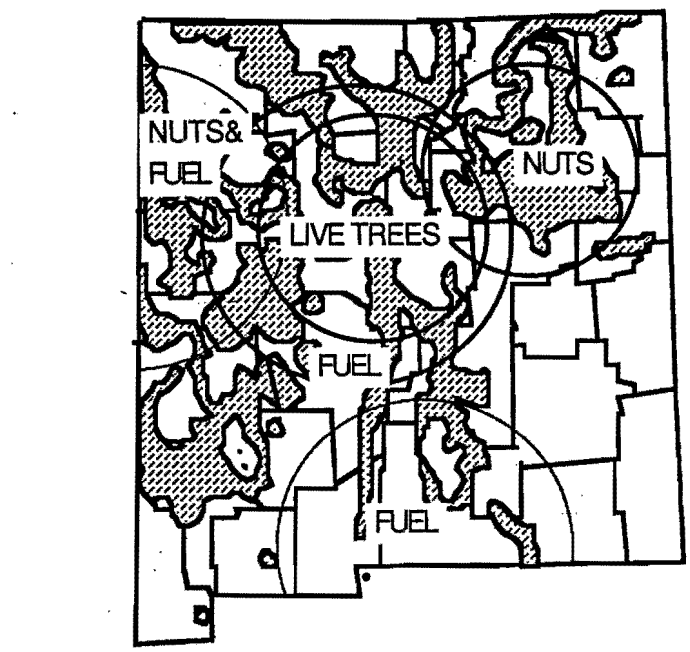

Fig. 7. Piñon-juniper woodlands "Wood Baskets" of sustained yield. The wood baskets are centered on outlets for the major products.

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