

# Management of Chaparral Habitat for Mule Deer and Mountain Sheep in Southern California<sup>1</sup>

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There is a huge crevasse that separates the zoological field of wildlife management from the botanical field of wildlife-habitat management. Despite the fact that each field is greatly dependent upon the other, each marches on his own side, not aware that they should do more than gaze coyly at the other from a distance.

F. E. Egler, 1974

In southern California, vegetation most commonly referred to as "chaparral" dominates wildland ecosystems. Chaparral generally occurs on cismontane slopes, primarily between 1,200 and 2,500 meters elevation. The species composition of chaparral is diverse, and most species are fire-adapted (Gill 1977), or otherwise adaptable to the application of chemical and mechanical management strategies (see Roby and Green 1976, Green 1977a, and Leisz and Wilson 1980).

Until recently, land management agencies approached chaparral manipulation from a fuels management aspect. Aside from the construction of fuel breaks and occasional type conversion projects, land management was dominated by fire prevention and suppression activities. The disastrous results of the 1970 fire season led to the formulation of the Laguna-Morena Demonstration Area in San Diego County (Newell 1979), and the concept of an active chaparral resource management program spread to other sites in southern California.

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<sup>1</sup>Presented at the Symposium on Dynamics and Management of Mediterranean-type Ecosystems, June 22-26, 1981, San Diego, California.

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Abstract: Mule deer (*Odocoileus hemionus*) and mountain sheep (*Ovis canadensis*) occur in chaparral habitats of the San Gabriel and San Bernardino mountains, California. While they inhabit similar vegetation types, differences in the physical characteristics of their habitats result in a general allopatry of these species. Management options applicable to deer habitat are not always practical in sheep habitat. A series of models which will assist managers with the design of projects to benefit these species is presented. Options for achieving these goals are presented, and constraints with which managers must deal are detailed and discussed.

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Because much of our public land is capable of producing more than one product, the multiple resource management philosophy is extremely important. As human populations increase, citizens place more and more demands upon public lands. Demands for commodities such as red meat, recreation sites, minerals, and energy increase daily. Consequently, intensive management of these resources is becoming increasingly important.

Wildlife biologists must be willing to provide input into all land management decisions if wildlife benefits and detriments are to be considered. Until now, predictive methods for assessing the potential impacts of vegetation management on wildlife habitat were not available. Multiple resource management needs an analytical system which allows the prediction of the effects of land management activities on wildlife habitats and, ultimately, on wildlife populations. Thomas (1979) and Salwasser and others (1980) have described the concept of a predictive wildlife habitat-oriented system which will allow more comprehensive assessments of land management actions on native wildlife species. The system in California is known as the Wildlife Habitat Relationships Program, and is a joint endeavor of many Federal and State agencies, as well as some private organizations. What follows is being developed as an aspect of the Wildlife Habitat Relationships Program, and is presented only in an exemplary manner.

In southern California, two large ungulates, mule deer (*Odocoileus hemionus*) and mountain sheep (*Ovis canadensis*), are major faunal elements of chaparral ecosystems. The objectives of this paper are to describe briefly the distribution and habitat requirements of these species, provide examples of various habitat management models which are being developed for the Wildlife Habitat Relationships Program, and discuss options and constraints in managing chaparral for wildlife.

Mule deer occur throughout the mountain ranges of southwestern California. Both resident and migratory populations are present. Winter ranges are generally between 400 and 2,500 meters elevation, and summer ranges between 2,000 and 3,600 meters (Longhurst and others 1952). Deer inhabit

diverse land forms, on slopes generally less than 60 percent. South aspects are preferred during winter, north aspects during summer (Taber and Dasmann 1958). A variety of vegetation types are utilized by deer (Longhurst and others 1952, Taber and Dasmann 1958). Chamise (*Adenostoma fasciculatum*) and mixed chaparral stands commonly are used below 2,400 meters elevation (Cronemiller and Bartholomew 1950). Water generally is available within 800 meters of occupied habitats.

Mountain sheep occur in the San Gabriel and San Bernardino Mountains. Both resident and migratory populations are present (Weaver and others 1972, DeForge 1980). Winter ranges generally are between 1,200 and 2,400 meters elevation and summer ranges between 2,000 and 4,500 meters. Approximately 70 percent of the observations (Holl and others 1980) showed mountain sheep used slopes from 50-90 percent, having south or southeast aspects, and supporting vegetation dominated by chaparral whitethorn (*Ceanothus leucodermis*), mountain mahogany (*Cercocarpus betuloides*), and chamise. Mean shrub cover is approximately 30 percent and herbaceous cover is less than 5 percent (Light and Weaver 1973). Water usually is available within 400 meters of occupied habitats.

#### DISCUSSION OF HABITAT MODELS

##### Background

While we cannot accurately predict the number of deer or sheep which a given vegetation type supports, we can predict population responses of these species to changes in the conditions of their habitats. The models presented here predict relative changes in deer and sheep populations with respect to the potential capabilities of chaparral vegetation (table 1). A high capability habitat would potentially support a relatively dense population, or a population of lesser density but which exhibits a high recruitment rate. Because of environmental resistance, the actual population in a high capability habitat may not exhibit high productivity, but this does not alter the habitat's (i.e., the vegetation's) potential. A low capability habitat would not support a dense, self-sustaining population; if it contains a population, some individuals would, by definition, be immigrants from other higher capability habitats.

There are several important management implications in the concept of defining seasonal habitat capability in terms of its contribution to population recruitment. Each seasonal range has a finite supply of forage and cover resources. If that supply is sufficient to support a deer population, any excess individuals will disperse to other available habitats. Among sheep, the tendency to disperse appears to be more limited (Geist 1971). There is, however, increasing evidence that mountain sheep may occupy newly available suitable habitats (Bleich and others 1980, Campbell and Remington 1979, Holl and others 1980, Riggs and

Table 1--Habitat capability as described by selected population parameters.

Habitat Capability	Population Parameters		
	Density	Recruitment Mortality	Emigration
High	Increasing or stable	≥ 1	Yes
Moderate	Stable	~ 1	No
Low	Decreasing	<1	No

Peek 1980), and this could be of paramount importance in future sheep habitat management decisions.

Where deer find other adjacent, unstocked but high capability habitat, they may increase to their tolerance density and produce more dispersers. On deer summer ranges, this leads to rapid colonization of newly available habitats, but only when there are sufficient high-capability ranges to produce dispersers. When high capability summer ranges are missing, new habitats may not be readily colonized for lack of dispersers.

On winter ranges of both species, carrying capacity may be exceeded because there often is no other suitable habitat available. Managers should attempt to balance the capacities of all seasonal ranges. High capability winter ranges are able to support positive recruitment only if the summer ranges provide healthy animals.

Perhaps the most significant implication of this concept for land management is the importance of identifying high capability seasonal ranges and either maintaining or recreating their characteristics. This is a distinct alternative to applying non-site-specific prescriptions to all lands within a herd's seasonal range. Moderate capability ranges should be targeted for enhancement. Low capability ranges should be treated only if they have a reasonable potential for improvement and they are adjacent to high capability habitat.

Within each seasonal range there are distinct habitat elements and attributes which determine its capability. Selected aspects of these attributes will be addressed in the habitat models. We will focus on the following:

Vegetation Stage: A designation of the existing vegetation, its age class and canopy cover.

Canopy Cover of Dominant Plants: Percent canopy cover of plants describing the vegetation type.

Stand Size: The area, in hectares, of a distinct stand of vegetation.

Cover and Forage Proportions: The proportion of an area in vegetation stands that meet cover standards, and the proportion in vegetation stands that provide forage but do not meet cover standards. The proportions apply to stands within a delineated seasonal range. Standards

for thermal and hiding cover differ by vegetation type and season of use. Stand area, canopy cover of dominant plants, and species composition of stands qualifying for cover designation must be stated for each seasonal habitat model.

In order to understand the models, it is necessary to consider the following definitions:

Forage Area: A vegetation stand, or group of stands, that provides high quality forage, but lacks structure which meets thermal or hiding cover requirements.

Thermal Cover Area: A vegetation stand, or group of stands, containing shrubs or trees that, because of their growth form, height, and canopy cover, are able to moderate temperature extremes. Such stands may also provide forage.

Deer Hiding Cover: Any stand of vegetation that is capable of hiding 90 percent of an adult deer from human view at a distance of less than or equal to 70 meters.

Sheep Escape Terrain: An area of steep, rocky terrain, lacking dense vegetation and which allows a sheep an unobstructed view for at least 100 meters.

Because chaparral vegetation is such an important component of the habitats of mountain sheep (Roll and others 1980) and mule deer (Longhurst and others 1952), it was selected as the example for which management models would be presented. That chaparral is so important from the standpoint of fire management (Philpot 1979) and the numerous techniques available for manipulation (Menke and Villaseñor 1977, Green 1977a, Green 1977b, Biswell 1977) are additional factors which influenced our selection. We have further limited our discussion to the winter and spring, and we use the following dates and characteristics to describe these seasons:

Winter: December 22-March 21; highest rainfall and coolest temperatures. Grasses are green and growing.

Spring: March 22-June 21; little rain and warming temperatures. Grasses are drying, forbs are flowering, and browse species are initiating new growth and flowering.

#### Chaparral Habitat Models

On chaparral ranges, forage values generally are high during the spring and moderate during the winter. Deer hiding cover is high year round, and winter-spring thermal cover is considered high for both deer and sheep. The value of a chaparral range as sheep escape terrain is related to the geomorphology of the area and is an inverse function of shrub density. As such, it is difficult to rate chaparral vegetation as escape terrain for sheep, except to say that less dense stands are better than higher density stands. High quality deer hiding cover is poor quality sheep escape terrain; the converse also is true.

The following models (figures 1-5) are based on our personal experiences and a review of the lit-

erature, and portray the relative value of chaparral ranges to deer and sheep populations. Sheep escape terrain, rather than deer hiding cover, was considered when evaluating vegetation parameters for sheep populations.

Relative to percent canopy cover, thermal and hiding cover values are similar year round on chaparral ranges, but marked seasonal differences occur in the relative forage value to deer on a seasonal basis (fig. 1). During winter and spring, forage value peaks at perhaps 20 percent canopy cover and then declines gradually. This is a function of the large amount of herbaceous material produced on these ranges, particularly at low densities of perennial plants. The relative forage value for deer remains relatively high up to about 50 percent canopy cover. Because percent canopy cover is closely related to age class, and concomitantly to forage quality, relative forage value to deer declines rapidly as canopy cover exceeds 50 percent. Cover values are not high until a minimum of 50 percent cover is attained.

The relative forage value of chaparral winter and spring ranges to mountain sheep is nearly identical to that of deer, except that value decreases more rapidly as crown closure increases (fig.1). The relative value of hiding and thermal cover is greatest when canopy cover is less than 15 percent. These values reflect the decided preference of mountain sheep for open shrub stands.

The relative value of chaparral habitat as a function of age class is shown in figure 2. Cover values are highest in mature, but not decadent chaparral. Forage value on winter and spring ranges are highest during early successional stages. This is related to the fact that young, vigorous chaparral shrubs have a higher forage value than do old, decadent shrubs (Taber and Dasmann 1958). Young, vigorous chaparral shrubs most commonly are found within five years of a fire.

For deer, relative value of chaparral habitat as a function of stand size is shown in figure 3. Thermal cover value is maximized between one and 8 hectares, while forage and hiding cover values peak at about 6 hectares and decline rapidly thereafter with increasing stand size. This primarily is a function of the stand becoming too large for deer to make effective use of ecotonal areas, where highly productive herbaceous habitats may provide additional high quality forage.

Vegetation patch size may not be a determinant of habitat quality for mountain sheep, owing to their affinity for steep, rocky terrain. Therefore, we have used the distance of vegetation stands from escape terrain in our model (fig.4). Forage value is greatest within 150 meters of escape terrain. Geomorphic features are the primary determinants of sheep thermal cover value; however, their value can be enhanced with a few large, scattered shrubs, up to about 15 percent canopy cover. Again, this reflects the preference of sheep for open terrain.

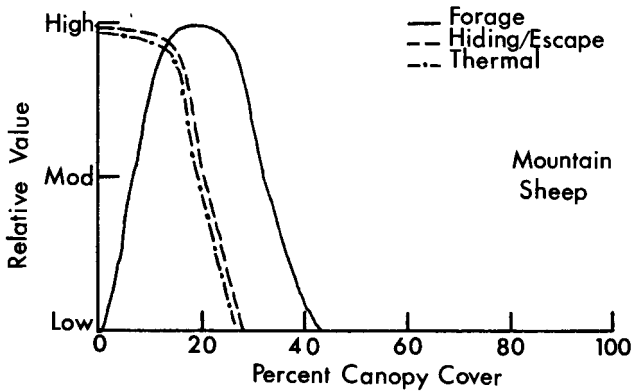
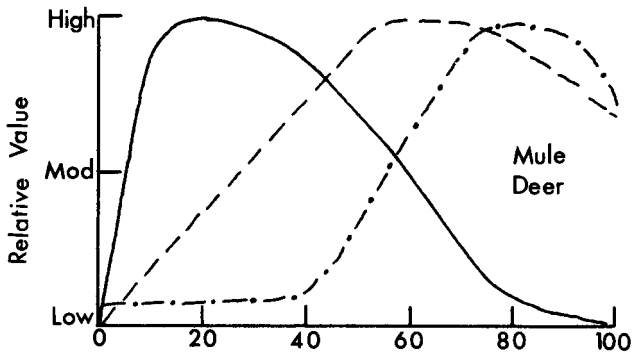


Figure 1. Relationship of percent canopy cover of chaparral vegetation to meet forage and cover requirements of mule deer and mountain sheep.

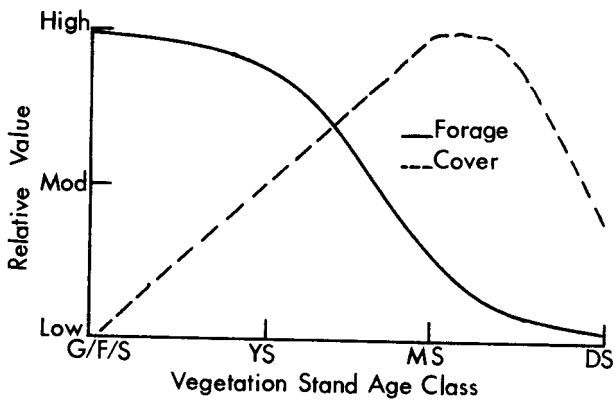


Figure 2. Relationship of vegetation stand age class of chaparral vegetation to meet forage and cover requirements of mule deer and mountain sheep.  
 G/F/S=Grass, forb, seedling  
 YS= Young shrub  
 MS= Mature shrub  
 DS= Decadent shrub

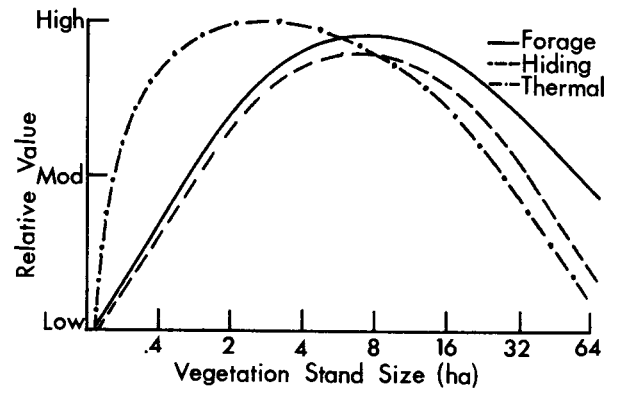


Figure 3. Relationship of size of chaparral vegetation stand to meet forage and cover requirements of mule deer.

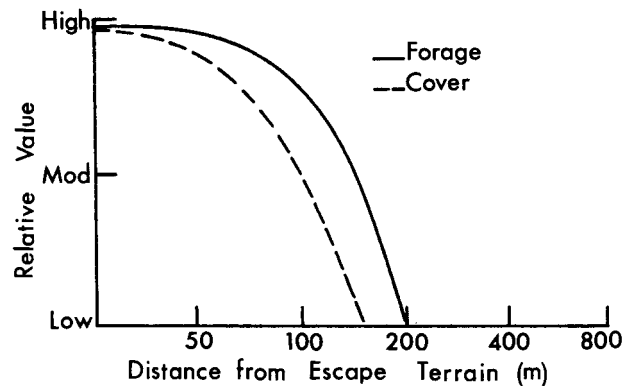


Figure 4. Relationship of distance of vegetation stand from escape terrain to meet forage and cover requirements of mountain sheep.

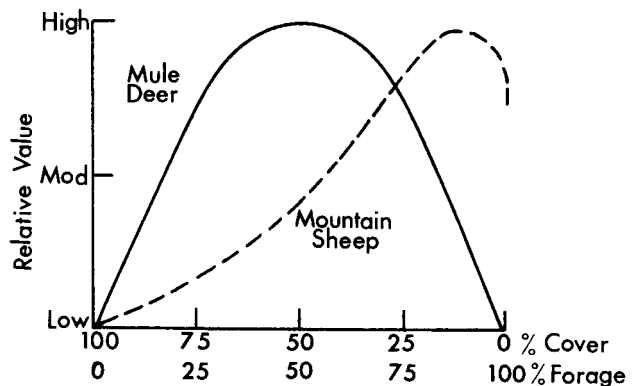


Figure 5. Relationship of cover/forage proportion of chaparral vegetation to meet forage and cover requirements of mule deer and mountain sheep.

The relative value of chaparral ranges for deer and sheep as a function of proportions in cover and forage is reflected in figure 5. It has been previously estimated (Taber and Dasmann 1958) that a cover and forage proportion of 50 percent of each is ideal for deer, while Thomas and others (1979) have suggested proportions of 40 percent and 60 percent.

The relative value of chaparral ranges as a function of the cover proportion is skewed to the right of that for deer (fig. 5). In this context, a shift to the right reflects a lower shrub density or lower percent crown cover. With a lower cover proportion a greater degree of openness is expected, thereby increasing the value to sheep because of their decided preference for more open habitats.

#### MANAGEMENT OPTIONS AND CONSTRAINTS

Managers can effectively manipulate wildlife populations through direct population manipulation or habitat modification (Caughley 1977, Scotter 1980). Direct population manipulation usually requires modification of existing harvest strategies; this subject will not be covered here. Habitat manipulation may be categorized as: (1) direct rehabilitation of ranges whose capability has declined because of natural processes or past management strategies; (2) direct enhancement of existing habitat; and (3) modification of other resource management practices (Scotter 1980).

Several methods of vegetation manipulation are available to the land manager interested in featuring deer or sheep. Each method produces varying effects and has different cost factors (table 2). The preferred method must be capable of producing the desired objectives for the wildlife population and vegetation structure and, whenever possible, be compatible with other resources.

Table 2--Some management options for vegetation manipulations in chaparral habitats, and predicted results.

Method	Approximate Cost/Hectare <sup>1</sup>		Probability of Successful Treatment <sup>2</sup>		Probability of Method Resulting in Conflicts With <sup>2</sup>	
	Light Fuel (<50 ton/hect.)	Heavy Fuel (>50 ton/hect.)	Deer Range	Sheep Range	Deer	Sheep
Mechanical	200-275	225-500	H	L	L	L
Chemical	50-75	125-190	H	H	L	L
Handwork	1125-3000	3500-6250	M	H	L	L
Livestock <sup>3</sup>			M	L	M	H
Burning	75	115	H	H	L	L

<sup>1</sup>Recent U.S. Forest Service Estimates (Dollars)

<sup>2</sup>H=High; M=Moderate; L=Low

Mechanical treatments such as disking, crushing, chaining, raking, and railing can be used to improve the productivity of desired forage species. However, the costs are relatively high (Roby and Green 1976, Green 1977a, and Yoakum and others 1980).

Erosion potentials following treatment are dependent on the method and the amount of vegetation removed. Brushrakes and ball and chain treatments may produce high erosion potentials, while a modified chain and disking treatment will produce the least. Additional treatments may be necessary following mechanical manipulation. Generally, mechanical treatments are desirable only on slopes less than 30 percent; however, a ball and chain may be used on slopes greater than 30 percent in suitable terrain (Roby and Green 1976, Green 1977b).

Properly planned mechanical treatments can result in irregular edges and leave islands of cover (Yoakum and others 1980). They are particularly suitable for chaparral ranges inhabited by deer, where optimum openings are 5-15 hectares in size. Mechanical treatment of vegetation on mountain sheep ranges generally is impractical because of the steep slopes and rugged terrain they inhabit.

Herbicides offer possibilities for improving wildlife habitat and some positive results have been obtained. However, wildlife habitats are composed of a variety of plant species which respond differently according to chemical concentrations and time of application. This often makes the use of sprays unpredictable in terms of their overall effect (Scotter 1980, Yoakum and others 1980). Chemical treatment of vegetation on chaparral ranges can be used as a preparation for burning, density reduction of impenetrable brush stands, or maintenance of low density brush stands.

The application of herbicides can be relatively inexpensive. They can be aerially broadcast or

<sup>3</sup>Costs vary with the species involved. Cattle often create a positive cashflow for the landowner; goats often create a negative cash flow.

selectively sprayed by hand in a variety of terrains. Close supervision is necessary to assure that target species are treated and drift is minimized (Roby and Green 1976, Green 1977b).

Indiscriminant application of herbicides can result in a loss of both cover and forage. Although no cases have been documented of lethal effects of herbicides when properly applied, certain chemicals possibly may cause abnormalities in some animals. It is possible that legal restrictions on the widespread use of herbicides will prevent their future application (Scotter 1980).

Handwork includes cutting shrubs and trees, grubbing root crowns, selectively applying herbicides, and planting. These treatments are feasible in all terrains and reduce soil disturbance to a minimum. Handwork is usually carried out in conjunction with other vegetation manipulation projects. This may include selectively spraying stumps and root crowns following prescribed burns or mechanical manipulation, or cutting control lines around prescribed burns. High manpower requirements and slow progress severely limit the practicability of handwork (Green 1977b).

Grazing practices and vegetation manipulation for domestic livestock can have significant effects on native ungulates. The effects may be positive or negative, depending on the timing and level of stocking, current range conditions, or the amount of habitat manipulated.

Competition for limited forage usually occurs among the most palatable species (Bryant and others 1979). On low capability chaparral ranges, competition for palatable species would be greatest with goats (Bryant and others 1979), moderate with domestic sheep (Longhurst and others 1979) and least with cattle. Heavy utilization of herbaceous forage by cattle may be detrimental to deer (Bowyer and Bleich, unpubl. data); however, as long as sufficient forage of all categories are available, competition is not likely to occur (Longhurst and others 1979).

Modification of grazing practices may be one of the best tools for improving deer forage. For example, Biswell and others (1952) discussed the use of domestic sheep to augment control of shrub regrowth on disturbed ranges where the deer population was inadequate to do so. This would maintain an open shrub community interspersed with grasses and forbs. Longhurst and others (1979) concluded that deer grazing alone did not maintain herbaceous ranges in the most productive condition for deer and that livestock could be utilized to achieve this objective. Additionally, the judicious use of cattle can be used to provide flexibility and control of browsing on deer ranges (Gibbens and Schultz 1962). Thus, both livestock and wild ungulate grazing are useful to maintain the desired seral stage of a plant community (Longhurst and others 1976, Scotter 1980).

We recommend caution when attempts are made to integrate grazing practices with mountain sheep.

The rugged terrain inhabited by mountain sheep inhibits herding of domestic stock, and the low forage production of many sheep ranges increases the possibility of competition. Additionally, mountain sheep are extremely susceptible to diseases of domestic stock, and these diseases have been implicated in several recent, major die-offs of mountain sheep (Foreyt and Jessup 1980, Jessup 1981).

Prescribed burning is recognized as a viable and economical tool for vegetation management on wild ungulate ranges (Yoakum and others 1980). Prescribed burning is applicable in a variety of vegetation types and in a variety of terrains. Not only do fires create a mosaic of vegetation structures between vegetation types, they will also create a mosaic within types (Lyon and others 1978). With the advent of the helitorch, prescribed burning can now be conducted under conditions which in the past would have been impossible.

Early work on northern California chaparral ranges documented the beneficial effects of prescribed burning on the productivity of deer populations (Biswell and others 1952, Taber and Dasmann 1957, Taber and Dasmann 1958). More recently, Longhurst and Connolly (1970) have also shown an increase in deer harvest within recently burned ranges. The value of burning on mountain sheep ranges has also now been recognized (Stelfox 1971, Peek and others 1979, Riggs and Peek 1980, Holl and others 1980).

While burning may be a highly desirable management tool, it may not be applicable under all circumstances (Leisz and Wilson 1980). Additionally, Longhurst and others (1976) questioned the cost/benefit ratio of burning chaparral ranges solely to benefit wildlife. These authors concluded that additional multiple use benefits should accrue to make prescribed burning economically justifiable.

#### SUMMARY

A cursory analysis of habitat utilization of mule deer and mountain sheep shows that their preferences are different. Different models are necessary to describe the habitat requirements of these two species. The models designed for management of deer habitat stressed vegetation structure and composition. Models designed for management of mountain sheep habitat emphasized both geomorphic and vegetative features. Management opportunities are more liberal for mule deer; however, the preferred habitat management technique for either species should be integrated with other resource management objectives.

#### LITERATURE CITED

Biswell, H. H. Prescribed fire as a management tool. *In*: Mooney, H. A.; Conrad, C. E., tech. coords. *Proc. Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems*. Berkeley, Calif.: Pacific Southwest For-

- est and Range Exp. Sta., Forest Service, U.S. Dep. Agric.:1977; Gen. Tech. Rep, WO-3:151-162.
- Biswell, H. H., R. D. Taber, D. W. Hedrick and A. M. Schultz. Management of chamise brushlands for game in the north coast region of California. Calif. Fish and Game 38:453-484; 1952.
- Bleich, V. C., L. J. Coombes and J. H. Davis. Big game guzzler evaluations: progress report II. Long Beach, Calif.: California Dep. Fish and Game; 1980. 19p.
- Bryant, F. C., M. M. Kothman and L. B. Merrill. Diets of sheep, angora goats, Spanish goats, and white-tailed deer under excellent range conditions. J. Range Manage. 32:412-417; 1979.
- Campbell, B. H. and R. Remington. Bighorn use of artificial water sources in the Buckskin Mountains, Arizona. Desert Bighorn Council, Trans. 1979:50-56; 1979.
- Caughley, G. Analysis of vertebrate populations. New York: John Wiley and Sons; 1977. 200p.
- Cronmiller, F. P. and P. S. Bartholomew. The California mule deer in chaparral forests. Calif. Fish and Game 36:343-365; 1950.
- DeForge, J. R. Ecology, behavior, and population dynamics of desert bighorn sheep, Ovis canadensis nelsoni, in the San Gabriel Mountains of California. Unpubl. M.S. Thesis, California Polytechnic State Univ., Pomona; 1980. 133 p.
- Egler, F. E. Wildlife habitat management, and deer. Ecology 55:684-685; 1974.
- Foreyt, W. and D. A. Jessup. Fatal pneumonia of bighorn sheep following introduction of domestic sheep. J. Wildl. Dis.: submitted; 1981.
- Geist, V. Mountain sheep. Chicago, Ill.: Univ. Chicago Press; 1971. 383 p.
- Gibbens, R. P. and A. M. Schultz. Manipulation of shrub form and browse production in game range improvement. Calif. Fish and Game 48:49-64; 1962.
- Gill, A. M. Plant traits adaptive to fires in Mediterranean land ecosystems. In: Mooney, H. A.; Conrad, C. E., tech. coords. Proc. Symp. Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems. Berkeley, Calif.: Pacific Southwest Forest and Range Exp. Stn., Forest Serv., U. S. Dep. Agric.: 1977; Gen. Tech. Rep. WO-3:17-26.
- Green, L. R. Fuel reduction without fire--current technology and ecosystem impact. In: Mooney, H. A.; Conrad, C. E., tech. coords. Proc. Symp. Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems. Berkeley, Calif.: Pacific Southwest Forest and Range Exp. Stn., Forest Serv., U.S. Dep. Agric.: 1977a; Gen. Tech. Rep. WO-3:163-171.
- Green, L. R. Fuelbreaks and other fuel modification for wildland fire control. Washington, D.C.: Forest Serv., U.S. Dep. Agric.: 1977b; Agric. Handb. 499. 79 p.
- Holl, S. A., V. C. Bleich, B. Rios and M. Brayton. San Gabriel bighorn sheep project, annual report. San Bernardino, Calif.: Forest Serv., U.S. Dep. Agric.: San Bernardino Nat. Forest; 1980. 42 p.
- Jessup, D. A. Pneumonia in bighorn sheep: effects on populations. Cal-Neva Wildl., Trans. 1981: in press; 1981.
- Leisz, D. R. and C. C. Wilson. To burn or not to burn: fire and chaparral management in southern California. J. For. 78:94-95; 1980.
- Light, J. T. and R. A. Weaver. Report on bighorn sheep habitat studies in the area for which an application was made to expand the Mount Baldy facility. San Bernardino, Calif.: Forest Serv., U.S. Dep. Agric.: San Bernardino Nat. Forest; 1973. 39 p.
- Longhurst, W. M. and G. E. Connolly. The effects of brush burning on deer. Cal-Neva Wildl., Trans. 1970:139-155; 1970.
- Longhurst, W. M., G. E. Connolly, B. M. Browning and E. O. Garton. Food interrelationships of deer and sheep in parts of Mendocino and Lake counties, California. Hilgardia 47:191-247; 1979.
- Longhurst, W. M., E. O. Garton, H. F. Heady and G. E. Connolly. The California deer decline and possibilities for restoration. Cal-Neva Wildl., Trans. 1976:74-103; 1976.
- Longhurst, W. M., A. S. Leopold and R. F. Dasmann. A survey of California deer herds. Sacramento, Calif.: California Dep. Fish and Game: 1952; Game Bull. 6. 136 p.
- Lyon, L. T., and others. Effects of fire on fauna. Washington, D. C.: Forest Serv., U.S. Dep. Agric.: 1978; Gen Tech. Rep. WO-6. 41 p.
- Menke, J. W. and R. Villasenor. The California Mediterranean ecosystem and its management. In: Mooney, H. A.; Conrad, C. E., tech coords. Proc. Symp. Environmental Consequences Fire and Fuel Management in Mediterranean Ecosystems. Berkeley, Calif.: Pacific Southwest Forest and Range Exp. Stn., Forest Serv., U. S. Dep. Agric.: 1977; Gen. Tech. Rep. WO-3:257-270.
- Newell, L. A. Managing chaparral. San Diego, Calif.: Forest Serv., U.S. Dep. Agric.: Cleveland Nat. Forest; 1979. 55 p. + appendices.
- Peek, J. M., R. A. Riggs and J. L. Lauer. Evaluation of fall burning on bighorn sheep winter range. J. Range Manage. 32:430-432; 1979.
- Philpot, C. W. Fire dynamics in chaparral. Cal-Neva Wildl., Trans. 1979:102-103; 1979.
- Riggs, R. A. and J. M. Peek. Mountain sheep habitat-use patterns related to post fire succession. J. Wildl. Manage. 44:933-938; 1980.
- Roby, G. A. and L. R. Green. 1976. Mechanical methods of chaparral modification. Washington, D.C. Forest Serv., U.S. Dep. Agric.: 1976; Agric. Handb. 487. 46 p.
- Salwasser, H., J. C. Capp, H. Black, Jr., and J. F. Hurley. The California wildlife habitat relationships program: an overview. In: DeGraff, R., tech. coord. Proc. Workshop Management Western Forests and Grasslands for Nongame Birds. Ogden, Utah: Intermountain Forest and Range Exp. Stn., Forest Serv., U.S. Dep. Agric.: 1980; Gen Tech. Rep. INT-86:369-378.
- Scotter, G. W. Management of wild ungulate habitat in the western United States and Canada: a review. J. Range Manage. 33:16-27; 1980.
- Stelfox, J. C. Bighorn sheep in the Canadian Rockies: a history 1800-1970. Can. Field-Nat. 85:101-122; 1971.
- Taber, R. D. and R. F. Dasmann. The dynamics of three natural populations of the deer Odocoileus hemionus columbianus. Ecology 38:233-246; 1957.

- Taber, R. D. and R. F. Dasmann. The black-tailed deer of the chaparral. Sacramento, Calif.: California Dep. Fish and Game: 1958; Game Bull. 8. 163 p.
- Thomas, J. W., tech. ed. Wildlife habitats in managed forests. Washington, D.C.: Forest Serv., U.S. Dep. Agric.: 1979; Agric. Handb. 553.
- Thomas, J. W., H. Black, Jr., R. J. Scherzinger and R. J. Pedersen. Deer and elk. In: Thomas, J. W., tech. ed. Wildlife habitats in managed forests. Washington, D.C.: Forest Serv., U.S. Dep. Agric.: 1979; Agric. Handb. 553:104-127.
- Weaver, R. A., J. L. Mensch, W. Timmerman and J. M. Hall. Bighorn sheep in the San Gabriel and San Bernardino Mountains. Sacramento, Calif.: Calif. Dep. Fish and Game: 1972; Wildl. Manage. Admin. Rep. 72-2. 38 p.
- Yoakum, J. W., and others. Habitat improvement techniques. In: Schemnitz, S. D., ed. Wildlife Management Techniques Manual. Washington, D.C.: The Wildlife Society; 1980; 329-403.