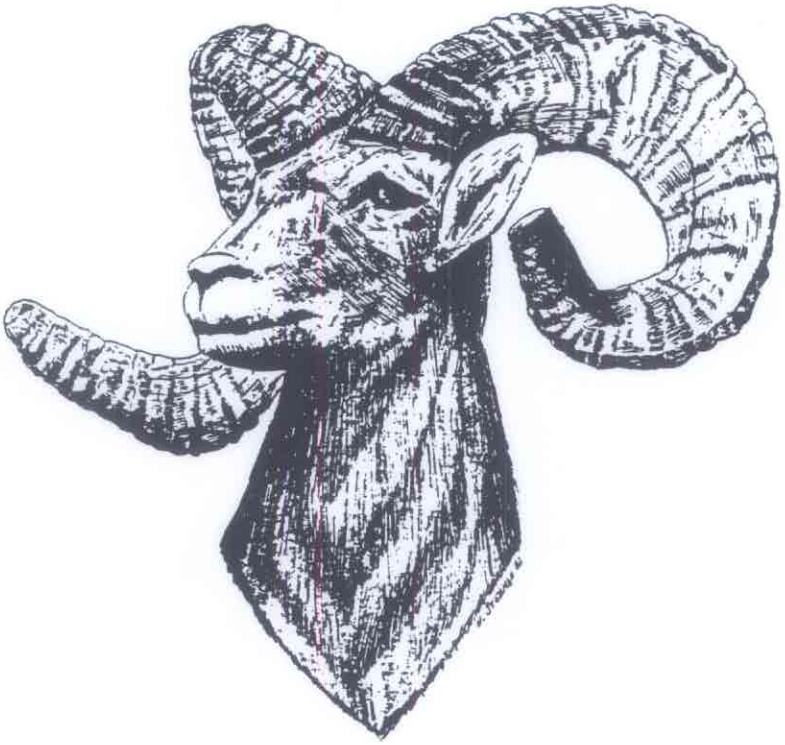
# Conservation Strategies for Bighorn Sheep in the San Gabriel Mountains, California



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## EXECUTIVE SUMMARY

A recent analysis of surveys conducted by the California Department of Fish and Game (CDFG) and U.S.D.A, Forest Service, (FS) indicated that the Nelson's bighorn sheep (*Ovis canadensis nelsoni*) population in the San Gabriel Mountains had declined approximately 88% since 1982.

Approximately 95% of the San Gabriel Mountains are public lands, administered by the Angeles and San Bernardino National Forests (ANF and SBNF). In response to the dramatic decline and high level of interest in this population, the Los Angeles County Fish and Game Commission requested than conservation strategies were evaluated for this population. This report describes the status of the bighorn sheep population in the San Gabriel Mountains and evaluates management direction and conservation strategies.

### Changes in Population Size

Three reports prepared between 1967 and 1972 estimated there were 500 bighorn sheep in the San Gabriel Mountains. By 1980, surveys provided a population estimate of 740±49 bighorn sheep; by 1988, the population had declined to an estimated 501±30 animals. Between 1995 and 2002, the population was estimated at 90 animals, with no more than 25 individuals in each of four groups in the mountain range.

### Factors Affecting the Population

Between 1972 and 1980 it was hypothesized that the population changes resulted from wildfires that burned between 1968 and 1975. Wildfires benefited bighorn sheep by increasing forage quality and the availability of escape terrain. The population decline that occurred after 1982 resulted from seral changes in chaparral vegetation that reduced the availability of escape terrain and forage quality. A similar population increase and decline occurred in mule deer (*Odocoileus hemionus*) that occupy these Forests.

The rapid decline in bighorn sheep that occurred between 1988 and 1995 could not be explained by habitat changes or disease; therefore, the only other potential explanation was predation. It is hypothesized that the mountain lion (*Puma concolor*) population in the San Gabriel Mountains increased because it was fully protected in 1972 and its primary prey species, mule deer, also increased following the wildfires in the early 1970's. When the mule deer population declined below a threshold, because of habitat changes and increased predation, mountain lions sought an alternative prey species, bighorn sheep. It appears that mountain lion predation has been reduced; however, it is still sufficient to prevent the bighorn sheep population from increasing.

### Population Viability

The San Gabriel Mountain bighorn sheep population is isolated from all other desert bighorn sheep populations. The closest population is 35 miles to the east in the San Bernardino Mountains. Opportunities for genetic exchange between these populations is remote because the populations are separated by large expanses of unsuitable habitat and the communities around Lake Arrowhead and Big Bear Lakes and Interstate Highway 15, an eight-lane freeway, provide substantial barriers to movement between these populations.

Conservation scientists have suggested that the minimum effective population size for large mammals should be 50 animals. The current effective population size for bighorn sheep in the San Gabriel Mountains is 60 animals. A review of other desert bighorn sheep populations indicated that groups of 16-30 individuals were extinct after 50 years. There are no more than 25 individuals in each of four groups in the San Gabriel Mountains. More recently, the risk of extinction within five years was estimated for ewe populations in the Peninsular Mountains that were also susceptible to mountain lion predation. Ewe groups of less than 15 individuals had a 60-70 percent chance of going extinct after five years. Three of the four groups in the San Gabriel Mountains have less than 15 ewes in them. These data indicate that the entire population of bighorn sheep in the San Gabriel Mountains is at the lower limit of sustaining itself over time. Groups on individual winter-spring ranges have high probabilities of being extirpated in the near future.

## Conservation Strategies

Based on the current status of the population, analysis of current management direction, and constraints and opportunities the following recommendations are provided to conserve the San Gabriel Mountain bighorn sheep population.

### Immediately List the Population as a Sensitive Species

Nelson's bighorn sheep were formerly listed by the Regional Forester as a sensitive species. The FS should immediately list the population as sensitive. Re-listing the population will ensure that impacts on bighorn sheep are thoroughly considered in all biological evaluations prepared for projects in bighorn sheep habitat. Additionally, listing as a sensitive species would increase the probability that their habitat was considered during preparation of a Wildland Fire Situation Analyses. This analysis is conducted on all fires that escape initial attack and it may allow some additional flexibility in suppression strategies that could result in some habitat restoration during unplanned ignitions.

### Prepare a Conservation Plan

An interagency group of biologists should prepare a conservation plan that can be implemented within one year. The plan should focus on strategies to increase the amount of management ignited prescribed fires in bighorn sheep habitat and identify the criteria that must be satisfied to remove mountain lions from bighorn sheep habitat. The plan should also address mitigation measures required to ensure that transportation projects do not result in habitat fragmentation. This plan should be adopted by CDFG and serve as a conservation agreement between FS and U. S. Fish and Wildlife Service (USFWS) to ensure the population is not federally listed under the Endangered Species Act.

### Initiate a Study of Mountain Lions

Mountain lion predation is precluding the bighorn sheep population from increasing. CDFG should immediately initiate a study to evaluate the occurrence of mountain lions in bighorn sheep habitat in the San Gabriel Mountains.

### Obtain Support for a Congressionally-Mandated Fuels Management Project in the San Gabriel Mountains

The national priority for fuels management is to reduce the threat of fires in the wildland-urban interface. The ANF and SBNF are adjacent to the largest metropolitan area in California; however, they receive substantially less funding for fuels management than northern Forests in more remote areas. Some of these northern Forests receive more funding because they have fuel management programs that are congressionally-mandated. A broad-based coalition of interest groups (e.g., local community leaders, environmentalists, watershed councils, sportsmen's groups) should prepare and obtain support for a pilot project in the San Gabriel Mountains that reduces fuel hazards and restores wildlife habitat for species, such as bighorn sheep, that occur in fire adapted ecosystems.

### List the San Gabriel Mountain Bighorn Sheep Population under the Endangered Species Act

If a conservation plan cannot be implemented within one year, the population should be listed as threatened or endangered. Listing the population will ensure that a recovery plan is developed and implemented to preserve and restore the population. Listing the population will increase interaction between the FS and USFWS because all activities proposed in bighorn sheep habitat will be reviewed to ensure the activities do not result in take, as defined in the ESA.

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# SECTION 1

## INTRODUCTION

A recent analysis of surveys conducted by the California Department of Fish and Game (DFG) and U.S.D.A, Forest Service, (FS) indicated that the Nelson's bighorn sheep (*Ovis canadensis nelsoni*) population in the San Gabriel Mountains had declined approximately 88% since 1982 (Holl et al. 2002).

The San Gabriel Mountains separate the Los Angeles metropolitan area from the Mojave desert. Approximately 95% of the mountain range is on public lands administered by the Angeles and San Bernardino National Forests (ANF and SBNF). Bighorn sheep occur in the eastern end of the mountain range, where the two primary land uses are multiple use and wilderness.

The population is well known to local naturalists, conservationists, and outdoor recreationists who frequent the trails on these Forests. Twenty years ago this population was large enough that animals were trapped and moved to unoccupied historic ranges. In response to the dramatic decline and high level of interest in this population, the Los Angeles County Fish and Game Commission contracted with Mr. Steve Holl to prepare an evaluation of conservation strategies for this population.

### Organization of the Report

This report is divided into three sections. Section 1, is the introduction. Section 2, describes the status of the bighorn sheep population in the San Gabriel Mountains. It includes a description of changes in population size, lamb recruitment, and adult survival; factors affecting the population; and a brief evaluation of population viability. Section 3, evaluates management direction and conservation strategies. Section 3, describes the current direction provided by state and federal agencies, evaluates management strategies to conserve the population, and provides management recommendations.

# SECTION 2

## STATUS OF THE SAN GABRIEL BIGHORN SHEEP POPULATION

This description of the San Gabriel bighorn sheep population is based on previous studies (Holl and Bleich 1983, Deforge 1980, Weaver et al. 1972, Light et al. 1967); annual surveys conducted by the CDFG and FS from 1979-2002; a manuscript that was submitted to the Wildlife Society Bulletin in July 2002 (Holl et al. 2002); and additional GIS analysis conducted by CDFG.

## Historical Accounts

Historical observations do not provide reliable population estimates of bighorn sheep in the San Gabriel Mountains. Estimates of 60 to 160 bighorn sheep in individual areas of the mountain range prior to 1920 suggests bighorn sheep were well distributed and locally abundant. The large number of anecdotal reports prior to 1950 indicates the population was well known to local hunters, naturalists, historians, and biologists. As additional comparative information became available during the 1970's, the San Gabriel population was recognized as the largest population of that subspecies.

## Recent Demographic Characteristics

### Distribution

The population is divided into four groups of sheep based on the location of winter-spring ranges and summer-fall ranges. The four groups are described below and the eight winter-spring ranges are identified in Figure 1. The boundaries of the winter-spring ranges were calculated by analyzing the density of groups of bighorn sheep observed between 1979 and 1988.

The Cucamonga Peak group includes sheep from the Middle and South Forks of Lytle Creek, and Deer, Cucamonga, and Barrett-Cascade Canyons winter-spring ranges. Their summer range includes Cucamonga, Ontario, Bighorn, Timber, and Telegraph Peaks.

The Mount San Antonio group includes bighorn sheep from Cattle Canyon, that summer on Bighorn Ridge, Mounts San Antonio and Harwood, and Dawson Peak. Rams may summer as far north as Wright Mountain.

The Iron Mountain group includes sheep from the East Fork of the San Gabriel River winter-spring range that summer on Iron Mountain, San Antonio Ridge, and Pine Mountain Ridge.

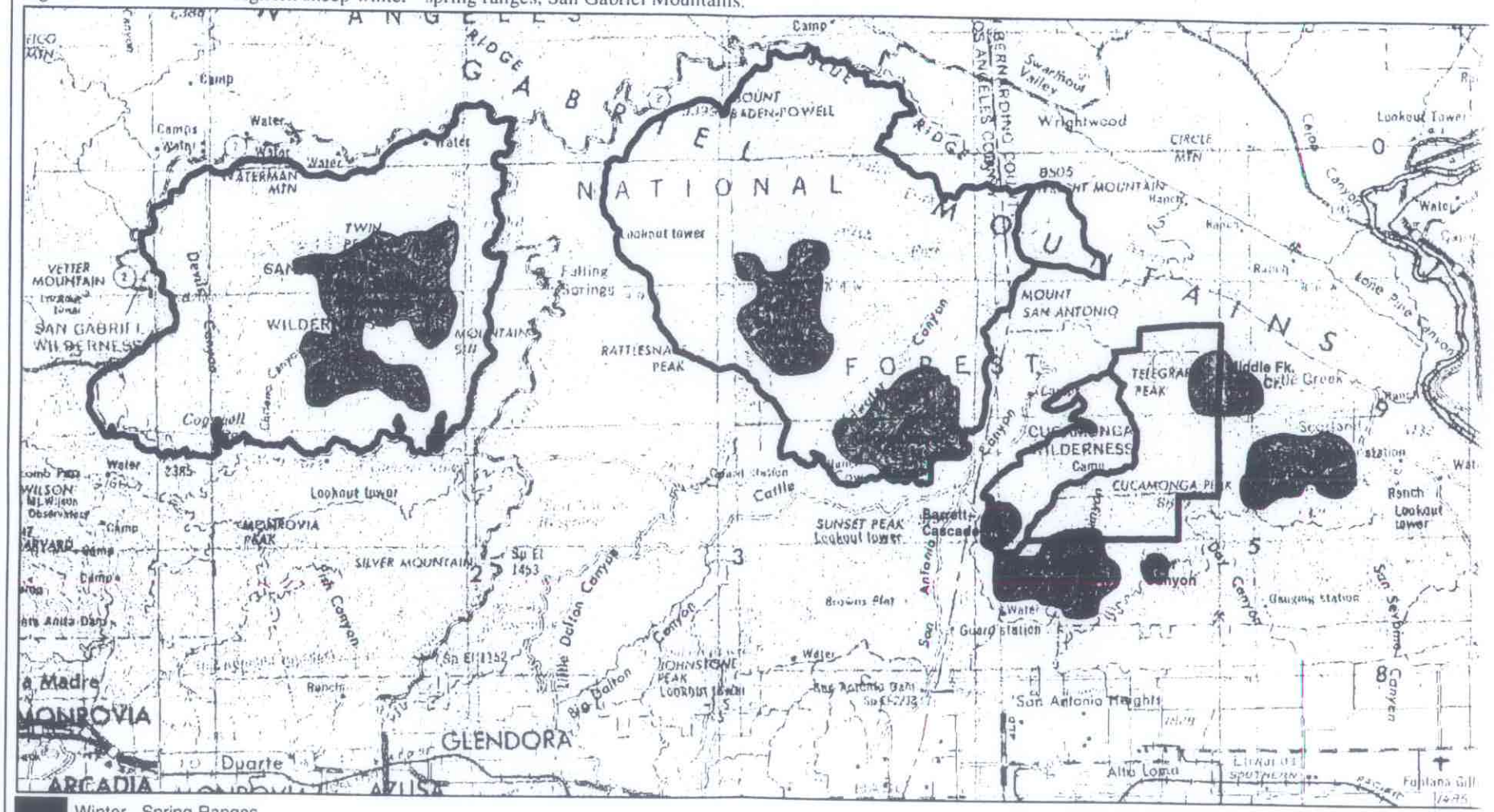
The Twin Peaks group includes sheep from the San Gabriel Wilderness that summer on Twin Peaks, Mount Waterman, Kratka Ridge, and the steep slopes along the northern portion of Highway 39.

There are no cultural barriers between any of the winter-spring ranges. Movement between seasonal ranges occurs along the extensive ridge systems that connect winter-spring and summer-fall ranges. The greatest amount of movement probably occurs during the breeding season by adult rams (October through November) (Holl and Bleich 1983).

### Population Size

CDFG and FS prepared three reports between 1967 and 1972 that provided estimates of approximately 500 bighorn sheep in the San Gabriel Mountains. The large estimates indicate

Figure 1. Distribution of bighorn sheep winter –spring ranges, San Gabriel Mountains.



bighorn sheep were abundant and the agreement in the estimates suggests the population was reasonably stable from 1967-1972.

In 1976, the population estimate was 665 bighorn sheep (Figure 2). The 1976 population estimates represent an estimated 33% increase from 1972 in the number of bighorn sheep in the San Gabriel Mountains.

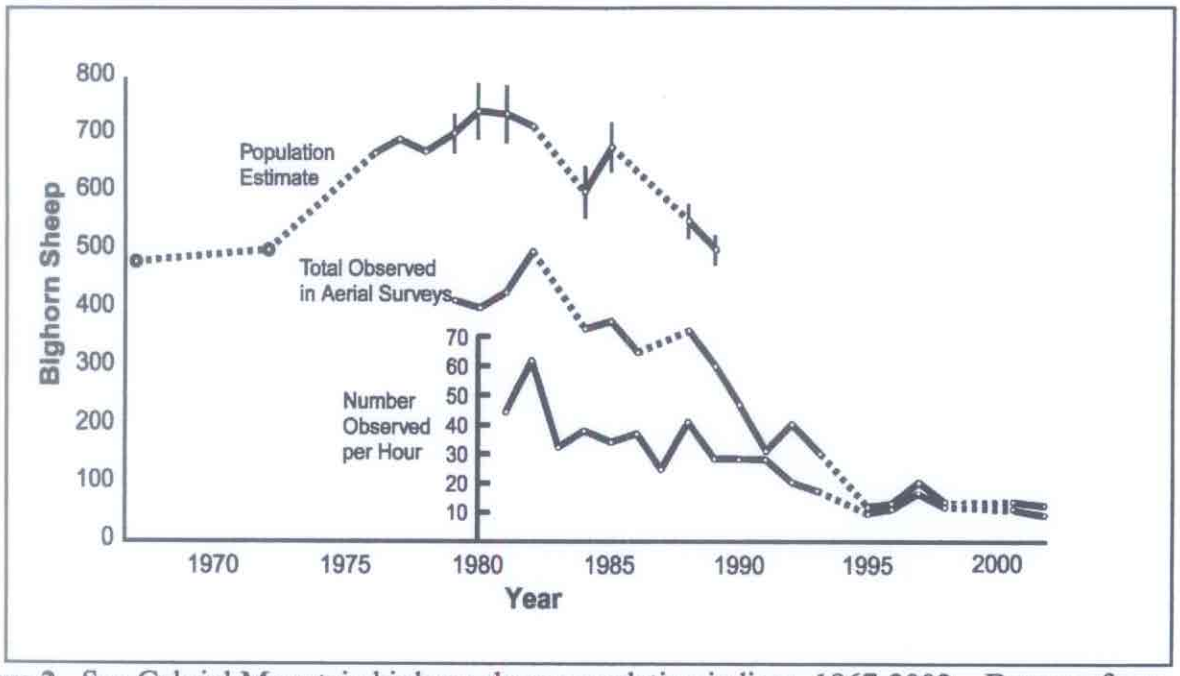



**Figure 2**. San Gabriel Mountain bighorn sheep population indices, 1967-2002. Data are from annual helicopter surveys conducted annually, in March.

From 1976-1982 the population increased slightly from previous years, with the highest estimate 740±49 bighorn sheep obtained in 1980 (Figure 2). After 1982, the population declined, and was estimated at 501±30 bighorn sheep in 1989.

Between 1989 and 1995 the number of bighorn sheep observed during each aerial survey declined from 301 to 62 and the number of bighorn sheep observed per hour helicopter time declined from 28 to 9 (Figure 2). Evaluation of changes on individual winter ranges indicated bighorn sheep populations declined substantially after 1988 in the Cucamonga Peak group. The population in Cattle Canyon declined substantially after 1993, and populations in the East Fork of San Gabriel River and San Gabriel Wilderness declined substantially after 1995. Between 1996 and 2002, the number of bighorn sheep observed during the surveys ranged from 106 to 63.

Estimated population sizes for each group of bighorn sheep were compared between 1976 and 1995-2002 (Table 1). These data indicate there was an 80-91% decline in the individual groups of bighorn sheep in the San Gabriel Mountains.

**Table 1**. Changes in the number of bighorn sheep by group in the San Gabriel Mountains.

| Group | Year | |
|---|---|---|
| | 1976 | 2002 |
| | Number of Bighorn Sheep | |
| Cucamonga Peak | 240 | 20 |
| Mount San Antonio | 130 | 25 |
| Iron Mountain | 130 | 25 |
| Twin Peaks | 160 | 20 |
| Total | 660 | 90 |

**Rates of Change**

Between 1976 and 1982, the rate of change was 0.015; at this rate, the population would double in approximately 44 years. Given this slow rate of increase, the population was considered stable. The estimated rates of change between 1982 and 1989, calculated from the population estimates and total number of bighorn sheep observed were similar (Table 2), indicating the population would halve approximately every 8 years.

**Table 2**. Rates of change and years for the population to halve using different population indices from 1982-1989, 1989-1995, and 1995-2002.

| Population Index | Rate of Change 1982-1989 | Years to Halve 1982-1989 | Rate of Change 1989-1995 | Years to Halve 1989-1995 | Rate of Change 1995-2002 | Years to Halve 1995-2002 |
|---|---|---|---|---|---|---|
| Population Estimate | -0.079 | 8.6 | -- | -- | -- | -- |
| Total Number Counted | -0.076 | 9.0 | -0.260 | 2.6 | -0.008 | 86 |
| Sheep Observed/ Hour of Flight Time | -0.010 | 6.5 | -0.228 | 3.0 | -0.018 | 36 |

From 1989-1995, the rates of change were more than twofold the rates calculated for 1982-1989, indicating the population would halve approximately every 2.8 years. From 1995-2002, the rates of change were negative; however, because the population changes would occur very slowly, it was considered stable.

## Adult Mortality

From 1979-1982, the total number of adult bighorn sheep counted was relatively consistent, ranging from 421-453 (Figure 3). However, the number of adult sheep declined between 1984 and 1995. The number of adult bighorn sheep counted from 1995-2002 changed little (mean±s.e.,74.6± 8.06) and is consistent with the stable population indicated by the rate of change.

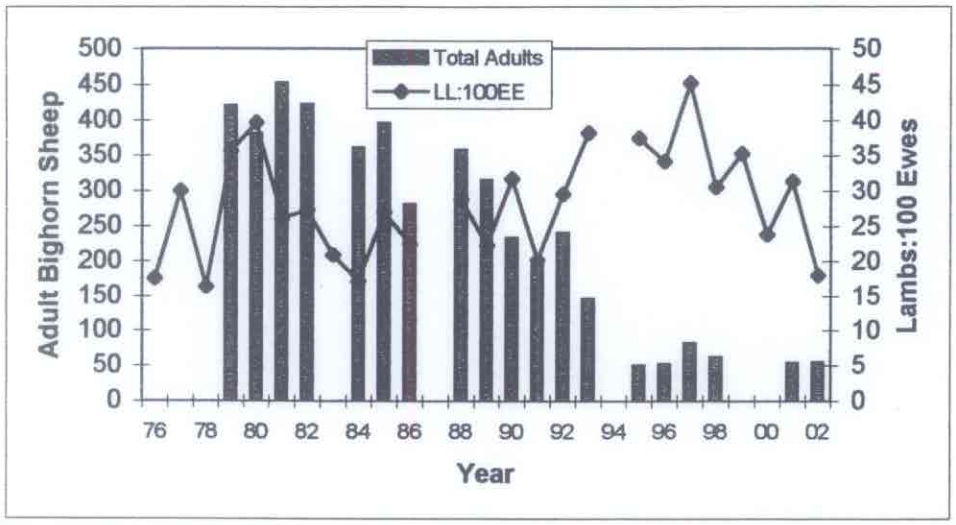



**Figure 3.** The number of adult bighorn sheep and lamb recruitment rates in the San Gabriel Mountains, 1976-2002.

## Lamb Recruitment

Lamb recruitment rates varied between 1976 and 2002 (Figure 3). Evaluations of lamb recruitment rates during different periods identified different factors that were associated with the observed recruitment rates.

**Lamb Recruitment 1976-1984.** A multiple regression model, using weather data from 1976 to 1984 explained 95% of the variance in lamb recruitment rates during this same period (Figure 4). High rainfall in November and December and warm, dry nights during lambing resulted in high lamb recruitment rates. Low rainfall during November and December and cold, wet nights during lambing resulted in low lamb recruitment rates. It was hypothesized that rainfall in November and December was surrogate for late winter and spring forage conditions. Rainfall and mean minimum temperatures in April and May coincided with lambing and based on other studies, it was hypothesized that hypothermia resulted in lamb mortality (Holl and Bleich 1983).

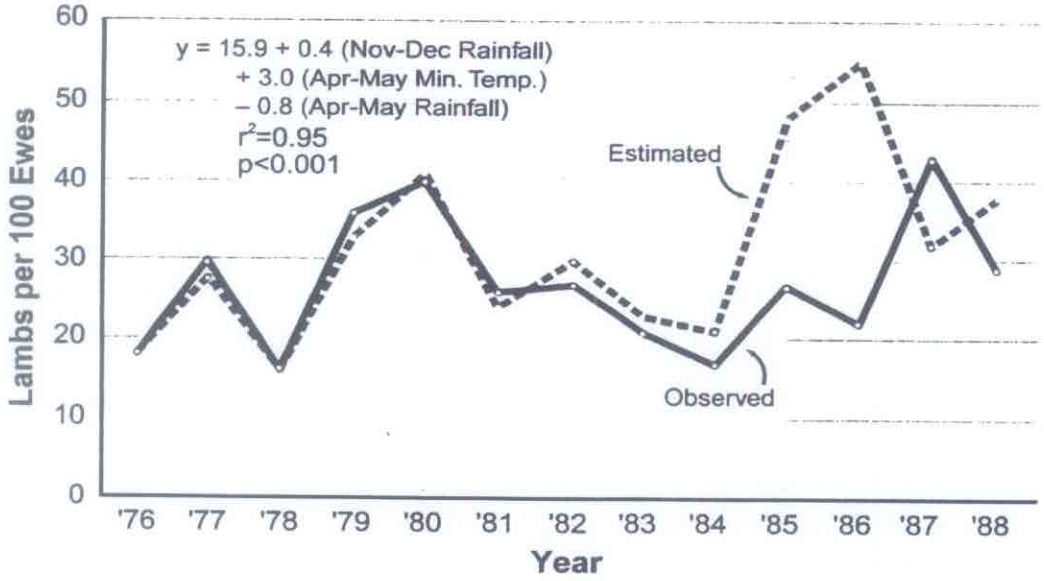



**Figure 4**. Observed and estimated lamb recruitment rates in the San Gabriel Mountains, 1976-1988. The equation is based on data from 1976-1984.

The significant correlation with weather data suggested that lamb recruitment rates from 1976-1984 were independent of population density. From 1985-1988, the predicted recruitment rates were generally lower and significantly different than the observed rates, suggesting a different factor affected recruitment rates after 1984.

**Lamb Recruitment 1985-2002**. Between 1985 and 2001 there was a significant relationship between lamb recruitment rates and the number of adult ewes (Figure 5), indicating that recruitment rates were inversely related to the number of adults ewes in the population. This density-dependent relationship is consistent with other studies of large ungulates where the population was not limited by habitat (McCullough 1979 and others). Lamb recruitment rates declined substantially in 2002 to 18LL:100EE. It is hypothesized that a lack of rainfall in November and December 2000, affected the production of grasses in spring 2001, which contributed to high neonatal mortality and subsequently, low recruitment.

## Factors Affecting Population Changes

When the annual surveys were initiated in 1976, over 180,000 acres had burned on the ANF and SBNF between 1968 and 1975. Fires in 1968 burned 667 acres in the South Fork of Lytle Creek winter spring-range. In 1970, 2,660 acres burned in Deer Canyon, Cucamonga Canyon and Barrett-Cascade Canyons winter-spring ranges. Approximately 1,925 acres in the Cattle Canyon winter-spring range burned in 1975.

During the early surveys bighorn sheep were observed using areas that had burned recently and avoiding areas of dense chaparral (Holl and Bleich 1983). Prior to 1988, we had not observed bighorn sheep in Big Mermaid Canyon in the San Gabriel Wilderness. During the

1988 annual survey, bighorn sheep were observed in Big Mermaid Canyon, which burned during the 1986 Telecote Fire. The 1998 fire in the East Fork of the San Gabriel provided additional evidence of bighorn sheep moving into recently burned areas. Between 1999 and 2002, four groups of sheep, totaling 10 animals, were observed in the burn area, north of their previously defined winter-srping range boundary.

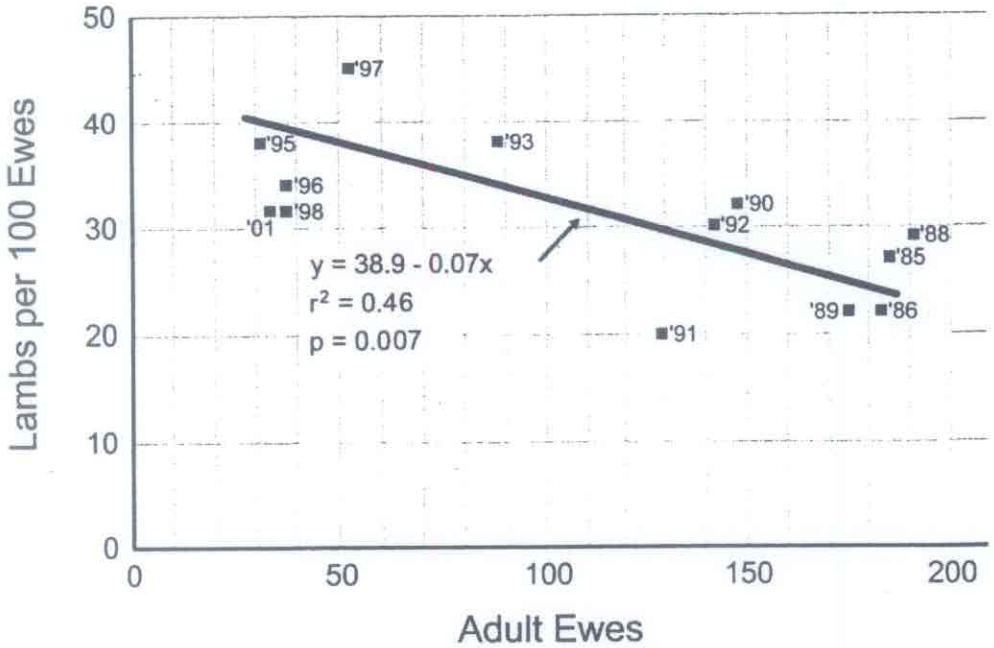



**Figure 5**. Relationship between lamb recruitment rates and the number of adult ewes, San Gabriel Mountains, 1985-2001.

The response of black-tailed deer (*O.h. columbianus*) to habitat changes resulting from wildfires in chaparral was described by Taber and Dasmann (1957, 1958). Changes in the number of bucks legally harvested in Los Angeles and San Bernardino Counties were evaluated between 1970 and 1998 to determine if this population responded similarly to the previous studies. Between 1974 and 1979 there was a 105% increase in the number of bucks harvested. The increase in buck harvest is consistent with habitat improvements resulting from the fires when a time lag is included that allows for an increase in fawn recruitment rates, growth to adulthood, and a sufficient increase in the number of bucks available for hunters to locate. The number of bucks harvested gradually declined from 1979-1989, which is also consistent with the decline in carrying capacity resulting from seral changes in chaparral.

Based on these observations, it was hypothesized that large-scale habitat changes in a fire-adapted ecosystem such as chaparral, could also account for the population changes in bighorn sheep observed between 1972 and 1989.

## Influence of Habitat Changes

Fire results in a short-term increase in the amount of herbaceous vegetation (Hanes 1971) and quality of browse (Taber and Dasmann 1957,1958). This would benefit bighorn sheep because grasses and browse comprise approximately 22% and 60%, respectively, of their annual diet in this mountain range (Perry et al. 1987). Fire also reduces the cover and visual obstructions associated with mature chaparral. This would benefit bighorn sheep because they prefer steep slopes with low vegetative cover (escape terrain) that does not restrict their vision to detect and avoid predators (Bleich and Holl 1982). There was also a positive, linear relationship between the amount of escape terrain available and the number of ewes that occurred on a winter-spring range (Holl and Bleich 1983). However, these habitat changes would be short-term because succession following the fire would reduce the quantity and quality of the available habitat.

From 1976-1982 the population was characterized by a low rate of change, low adult mortality and lamb recruitment rates that were affected by annual forage production and the weather during lambing. This response is consistent with the gradual change in carrying capacity associated with the increase in the amount of chaparral cover, that resulted in reduced forage quality of browse, the availability of grasses, and amount of escape terrain. After 1982, plant succession continued to reduce carrying capacity, resulting in increased adult mortality, lower than predicted lamb recruitment rates, and the population declined, at a rate of halving approximately every 8 years.

The 1975 fire in Cattle Canyon provided additional evidence of the effects of a wildfire on habitat suitability and the distribution of bighorn sheep. In Cattle Canyon the distribution of ewe groups observed during the annual survey in and out of burned areas changed significantly ($X^2 = 30.727$; 2 d.f.; $P<0.005$) between 1979 and 1997. Between 1979 and 1982 the number of ewe groups observed in and out of the burned area was similar (Table 3). Between 1983 and 1987 the number of groups in the burned area declined 53%, while the number of groups in the unburned area increased slightly. The reduction in the number of ewe groups observed in the burned area occurred approximately 8 to 12 years after the fire, which corresponds with the increase in the percent cover of common chaparral shrub species that follows a wildfire (Hanes 1971).

**Table 3**. Changes in the distribution of ewe groups in burned and unburned areas in Cattle Canyon.

| | 1979-1982 | 1983-1987 | 1988-1997 |
|---|---|---|---|
| Burned Area | 219 | 102 | 69 |
| Unburned Area | 239 | 247 | 131 |

The changes in the distribution of ewes in Cattle Canyon between 1979 and 1987 supports the hypothesis that habitat changes resulting from the wildfires of 1970 and 1975 effected the population changes observed between 1976 and 1989.

Between 1988 and 1997, there was a substantial decline in the number of all ewe groups observed in Cattle Canyon. This is consistent with the rapid population decline described for the remainder of the mountain range. It is unlikely that habitat changes accounted for the population decline observed after 1989. There were no landscape-level habitat changes after 1975 and the population decline also occurred in the Middle Fork of Lytle Creek, East Fork of the San Gabriel River, and San Gabriel Wilderness winter-spring ranges that were not affected by earlier wildfires. Additionally, the increase in lamb recruitment rates after 1993 and inverse, density-dependent relationship between lamb recruitment rates and the number of adult ewes observed between 1985 and 2001 indicates the population was below carrying capacity. This occurred even though plant succession had reduced carrying capacity on half of the winter-spring ranges. Therefore, the influence of habitat changes on the population after 1989 was dismissed and disease and predation were considered.

**Influence of Disease**

Epizootic die-offs of bighorn sheep populations have occurred throughout their range from high infestations of lungworm (*Protostrongylus spp.*), bacterial pneumonia associated with domestic sheep, and chronic sinusitis caused by domestic sheep bot flies. However, there have been no historical reports of these die-offs in the San Gabriel Mountains.

Lungworms were not detected in San Gabriel Mountain bighorn sheep; and the incidence in other desert populations is low because these arid habitats are not suitable for the intermediate host, a ground snail. Additionally, the probability of bighorn sheep in this mountain range ingesting ground snail is low. Ground snails occur in organic and are ingested by bighorn sheep when foraging on low-growing grasses and other herbaceous vegetation. Bighorn sheep in the San Gabriel's spend little time foraging in areas suitable to ground sails because approximately 60% of their annual diet is browse (Perry et al. 1987).

Bacterial pneumonia introduced from sympatric herds of domestic sheep has been implicated in significant population declines in numerous bighorn sheep populations. Bacterial pneumonia probably requires physical contact between domestic sheep and bighorn sheep (Foreyt and Jessup 1982). Very little livestock grazing occurred in this mountain range because there was little suitable grazing land, no livestock allotments were established in bighorn sheep habitat, and the ANF and SBNF Land and Resource Management Plans prohibited domestic sheep grazing within a minimum of two miles of bighorn sheep habitat (Angeles National Forest 1987, San Bernardino National Forest 1988). Domestic sheep have grazed on private land adjacent to the SBNF; however, the domestic animals are more than two miles away from bighorn sheep habitat. Therefore, the physical contact required for the transmission of bacterial pneumonia is only remotely possible in this mountain range.

Chronic sinusitis has been observed in desert bighorn sheep populations, including the San Gabriel Mountains (Deforge 1980). Bot flies deposit eggs in the nasal passages of bighorn sheep and bacterial infections in the nasal and frontal sinuses from migrating larvae lead to bone lesions, blindness, and enlarged horn bases. Although isolated infestations have been observed

in this population, the incidence is low because the disease is probably caused by the domestic sheep bot fly, and its traditional host, domestic sheep have not grazed in bighorn sheep habitat in this mountain range.

Blood samples from animals captured between 1983 and 1987 (n = 73) and tested for up to 12 different pathogens showed a low prevalence for infectious diseases (Clark et al. 1985, 1993). These data and the lack of known methods of transmission indicate that the conditions associated with die-offs described for other bighorn sheep populations probably do not exist in the San Gabriel Mountains. Additionally, the increase in lamb recruitment rates between 1993 and 1998 would be inconsistent with an epizootic die-off, where all age classes would be adversely affected. Therefore, no data are available to support the hypothesis that disease resulted in the rapid decline of bighorn sheep observed in the San Gabriel Mountains between 1989 and 1995.

**Influence of Predation**

Mountain lion (*Puma concolor*) predation has been identified as an important cause of mortality among bighorn sheep in New Mexico (Logan and Sweanor 2001) and California (Wehausen et al. 1996, Hayes et al. 2000, Schaefer et al. 2000), particularly in mountain ranges where mule deer and bighorn sheep are sympatric (Schaefer et al. 2000). Previous studies in the San Gabriel Mountains however, concluded that mountain lion predation was not a significant factor affecting mule deer or bighorn sheep (Cronemiller and Bartholomew 1950, Weaver et al. 1972, Deforge 1980, Holl and Bleich 1983).

More recently, the San Gabriel Mountains were identified as high to medium suitability mountain lion habitat (Torres et al. 1996). Additionally, the population decline in the San Gabriel Mountains coincided with high rates of mortality in other bighorn sheep populations in southern California caused by mountain lion predation (Wehausen 1996, Hayes et al. 2000, Schaefer et al. 2000) and the decline in the San Gabriel Mountains initially occurred in the Cucamonga group an area that historically supported large numbers of mountain lions (Hert and McMillin 1955).

Early records and stories of mountain lion trapping support the more recent habitat assessment of Torres et al. (1996). Between 1907 and 1963, 387 mountain lions were trapped for bounties in Los Angeles and San Bernardino Counties. The largest number was removed between 1921 and 1930 (n = 125) and the number of mountain lions removed declined in each successive decade (n = 90, 51, and 31). Many of these mountain lions were removed by trappers who relied on the bounty as all or a significant portion of their livelihood. Assuming that the catch-per-unit effort was similar in all years, the decline in the number of mountain lions claimed after 1930 suggests that the mountain lion population size declined substantially.

From approximately 1907 to 1944 the local trapper described numerous adventures about trapping mountain lions and observing bighorn sheep in the San Gabriel Mountains (Hert and McMillin 1955). As the San Bernardino Predatory Animal Control officer between 1920 and 1944, C. Hert claimed to have trapped over 110 mountain lions in the eastern end of the San

Gabriel Mountains and western end of the adjacent San Bernardino Mountains. Numerous accounts of these mountain lion trapping adventures were in bighorn sheep habitat and he observed groups of 40-50 bighorn sheep in the South Fork of Lytle Creek. By the 1950's Hert and McMillin (1955) concluded that mountain lions had been eliminated from the eastern half of bighorn sheep habitat in the San Gabriel Mountains. Their conclusion is consistent with the decline in the number of mountain lions turned in for bounties after 1930 and explains why previous studies stated mountain lions were not a significant predator of deer and bighorn sheep in this mountain range.

The mountain lion bounty system was discontinued in 1963 and lions have not been legally hunted in California since 1972; evidence indicates they have become more numerous and extended their range (Torres et al. 1996). After being protected in 1972, DFG did not issue a mountain lion depredation permit in Los Angeles or San Bernardino Counties until 1981. During the next 10 years, four depredation permits were issued; however, from 1993-1996, depredation permits were issued each year and the number of permits issued increased each year. The highest number issued was 5 in 1995 and 1996 which was similar to the statewide increase in permits issued in 1994 and 1995 in response to attacks on humans by mountain lions (Torres et al. 1996). Two to four permits were issued each year from 1997-2001.

Mule deer are the primary prey of mountain lions (Ballard et al. 2001); however, studies have shown that mountain lions will seek alternative prey after their primary prey has declined (Sweitzer et al. 1997, Logan and Sweanor 2001). Therefore, the relationship between population indices of mule deer and bighorn sheep was evaluated. There was a significant correlation in population changes between these species from 1982-1998. Both populations declined after 1979; however, the bighorn sheep population declined more rapidly than the deer population after 1989 (Figure 6). There was also a significant linear relationship between the number of bighorn sheep counted and the number of mountain lion depredation permits issued from 1989-2001 (Figure 7).

The relationships described above were used to formulate a hypothesis to explain the bighorn sheep population decline that occurred from 1989-1995. After the bounty system was eliminated and mountain lions were protected in 1972, the population gradually increased, as had been described throughout the state (Torres et al. 1996). The mountain lion population continued to grow in response to low adult mortality rates and the increased availability of mule deer that occurred after the fires in 1970 and 1975. By 1989, the mule deer population had declined, in response to deteriorating habitat quality and mountain lion predation, below a threshold and mountain lions were forced to seek alternative prey, such as domestic pets and livestock, which resulted in an increase in the number of mountain lion depredation permits issued. Additionally, mountain lions preyed on bighorn sheep resulting in the increase in adult mortality and the large decline in the bighorn sheep population observed after 1989.

A similar scenario has recently been observed elsewhere. In Nevada, the decline in mule deer coincided with the near extinction of a porcupine (*Erethrizon dorsatum*) population from mountain lion predation (Sweitzer et al. 1997). In New Mexico, increased predation of bighorn sheep by mountain lions coincided with a decline in the mule deer population (Logan and

Sweanor 2001). In the eastern Sierra Nevada the number of mule deer declined as a result of drought and a decline in the quality and quantity of forage (Kucera 1988); however, mountain lion population indices remained high. During the decline in the mule deer population, Wehausen (1996) reported a marked increase in mountain lion predation on bighorn sheep.

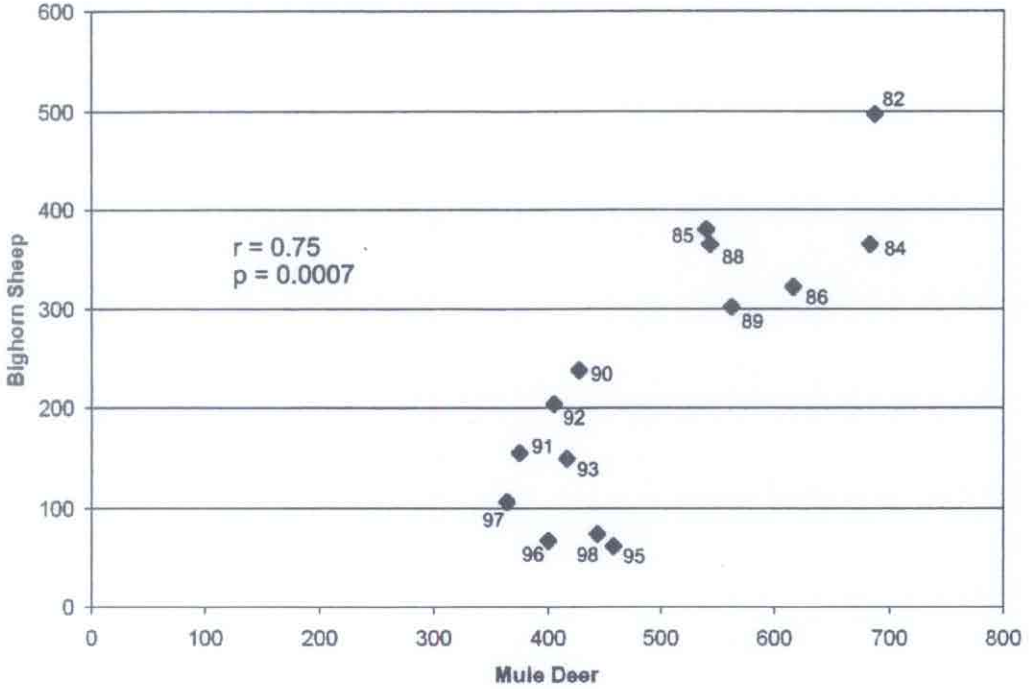



**Figure 6.** Relationship between bighorn sheep and mule deer in the San Gabriel Mountains, 1982-1998.

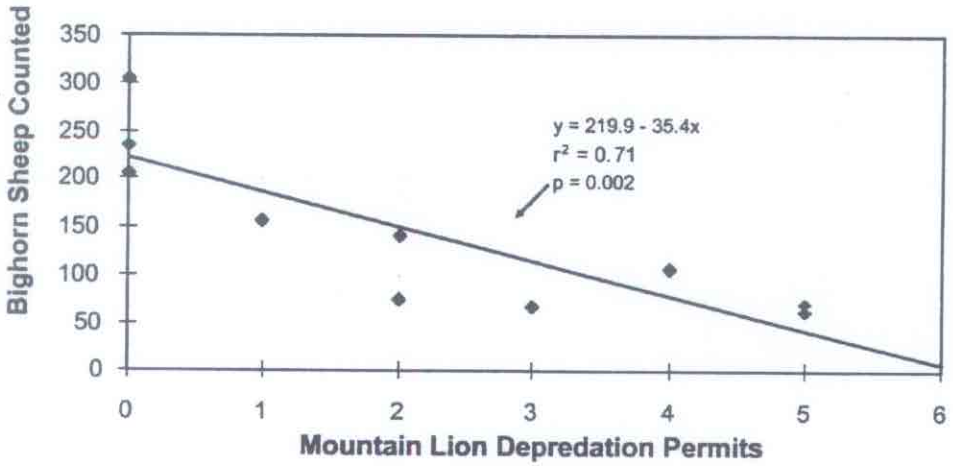



**Figure 7**. Relationship between bighorn sheep in the San Gabriel Mountains and mountain lion depredation permits in Los Angeles and San Bernardino Counties, 1989-2001.

Population surveys conducted in 1996-2002 indicated there was little change in the population of bighorn sheep in the San Gabriel Mountains. Lamb recruitment rates remained high, except in 2002; however, the number of adults changed little, indicating predation continued to affect adult mortality. This suggests that the effects of mountain lion predation had been reduced but not eliminated. Pierce et al. (2000) and Logan and Sweanor (2001) have shown that mountain lion populations are limited by prey availability. Therefore, the decline in large prey species, such as mule deer and bighorn sheep, would result in the decline in the predator population, as indicated by the reduction in the number of depredation permits issued by CDFG.

### Drought

Lamb recruitment rates in 2002 were 18LL:100EE, which is substantially below recruitment rates recorded since 1992. It is hypothesized that drought conditions contributed to these low recruitment rates and will affect lamb recruitment through 2003. Poor lamb recruitment will exacerbate the ability of the population to recover in the near future.

## Population Viability

The San Gabriel Mountain bighorn sheep population is substantially below historic estimates for this population. Based on early reports (Holl et al. 1983), it is likely that the population is currently smaller than it has been in the last 100 years.

Population viability assessments for individual species have used mathematical models and qualitative evaluations of threats to the population. A population viability assessment model was not developed for this population because the data required to build the model are not readily available and projections using current assumptions may not be applicable in the future. Therefore, population viability was assessed by evaluating the current status and recent trends in the population, its distribution, and by comparing the current size of the population to published reports that have evaluated the viability of other bighorn sheep populations.

### Viability Assessment

The San Gabriel Mountain bighorn sheep population is isolated from all other desert bighorn sheep populations. The closest population is 35 miles to the east in the San Bernardino Mountains. Opportunities for genetic exchange between these populations is remote because the populations are separated by large expanses of unsuitable habitat and the communities around Lake Arrowhead and Big Bear Lakes and Interstate Highway 15, an eight-lane freeway, provide substantial barriers to movement between these populations.

The number of adult ewes and mature rams (Class III = $\geq$ ¾ curl horns) for each group is described in Table 4. The number of mature animals is considered because these are the individuals that contribute to the reproductive capability of the population.

**Table 4**. Estimated number of adult ewes, mature rams, and effective population sizes in bighorn sheep groups in the San Gabriel Mountains.

| Group | Ewes | Class III+ Rams | Effective Population Size |
|---|---|---|---|
| Cucamonga Peak | 11 | 3 | 13 |
| Mount San Antonio | 13 | 5 | 16 |
| Iron Mountain | 17 | 3 | 18 |
| Twin Peaks | 11 | 3 | 13 |
| Total | 52 | 14 | 60 |

Franklin (1980) suggested that the minimum effective population size for large mammals should be 50 animals. The effective population size only considers the number of breeding adults. Assuming 90% of all ewes and all Class III males breed, the current effective population size is 60 bighorn sheep. Thus, the current effective population size is approaching the suggested minimum number.

Berger (1990) reviewed the persistence of 122 desert bighorn sheep populations. Populations of 51-100 individuals had a 50-60 % chance of persisting for 50 years. Groups of 16-30 individuals were extinct after 50 years. Population estimates for individual groups of bighorn sheep in the San Gabriel Mountains currently range from 20-25 animals. More recently, Ernest et al. (2002) estimated the risk of extinction within five years for ewe populations in the Peninsular Mountains that were susceptible to mountain lion predation. Ewe populations of 50 individuals did not go extinct after five years. However, ewe groups of less than 15 individuals had a 60-70 percent chance of going extinct after five years. The estimated number of ewes in individual groups in the San Gabriel Mountains currently range from 11-17 animals.

These data indicate that the entire population of bighorn sheep in the San Gabriel Mountains is at the lower limit of sustaining itself over time. Additionally, groups on individual winter-spring ranges have high probabilities of being extirpated in the near future.

# SECTION 3

## MANAGEMENT DIRECTION AND CONSERVATION STRATEGIES

This section describes current management direction for bighorn sheep, evaluates different conservation strategies, and provides recommendations for management of this population.

### Current Management Direction

#### State Direction

Management direction at the state-level is described in the California Fish and Game Code [CFGC].

**Fully Protected Species**. All subspecies of bighorn sheep in California are fully protected species (CFGC 4700), except designated populations of Nelson's bighorn sheep. Bighorn sheep in the San Gabriel Mountains have not been designated by the State Fish and Game Commission for legal hunting. As a fully protected species, individuals are prohibited to take a bighorn sheep and DFG may not authorize the take of a fully protected species.

**Bighorn Sheep**. Management direction for bighorn sheep is described in CFGC 4900-4904. It is state policy to encourage the preservation, restoration, utilization, and management of California's bighorn sheep. CDFG is required to determine the status and trend of populations by management units and develop a plan for each unit. The plan should include the following:

- Demographic information,
- A survey of range conditions and sources of competition,
- An assessment of the need to relocate or reestablish animals,
- A description of the prevalence of diseases, and
- Recommendations for achieving the state policy.

A statewide management plan was prepared by DFG for all bighorn sheep populations (California Department of Fish and Game 1983). This management plan is very broad and does not address the current situation in the San Gabriel Mountains.

#### Federal Direction

Management direction at the federal level is described in the implementing regulations for the National Forest Management Act (NFMA) and the ANF and SBNF Land and Resource

Management Plans (Angeles National Forest 1987, San Bernardino National Forest 1988). The Forests are currently revising their Land and Resource Management Plans; therefore, current and future planning regulations are described. At this time, it is estimated that the revised Land and Resource Management Plans will be approved in 2004.

**1982 NFMA Regulations**. The ANF and SBNF are required to maintain viable populations of existing native and desired non-native vertebrate species. Viable populations have the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the population is well distributed. Additionally, habitat must be provided and well-distributed to support a minimum number of reproductive individuals (Section 219.19).

**Management Indicator Species**. Bighorn sheep are management indicator species (MIS) on both Forests. MIS are selected because their population changes are believed to indicate the effects of management activities.

**2000 NFMA Regulations**. The following is a summary of requirements from Section 219.20 that the Forests must evaluate during the current planning process.

- Identify species that are at risk and focal species. Focal species provide insights to larger ecological systems. It is highly probable that bighorn sheep will be a focal species for the ANF and SBNF.
- Assess the risks to species viability and identify ecological conditions required to maintain those species over time.
- Provide the ecological conditions that result in a high likelihood of supporting the viability of native species that are well distributed. Species are well distributed when individuals can interact in the planning areas.
- Provide conditions capable of maintaining the viability of each population in naturally disjunct populations, such as the San Gabriel Mountain bighorn sheep.
- Implement actions in conservation agreements that provide a basis for not needing to list a species under the federal Endangered Species Act (ESA).

**1983 Administrative Report**

The administrative report (Holl and Bleich 1983) that summarized the knowledge of bighorn sheep in the San Gabriel Mountain, at that time, also provided a series of management guidelines and recommendations (Table 5).

Information in Table 5 was reviewed by CDFG and FS wildlife biologists in August, 2002. All but one of the guidelines are relevant today. Recommendation 5, a population management program is not relevant because the population is too small and cannot be sustained with additive mortality from regulated harvesting.

**Table 5.** Implementation status of 1983 management recommendations and guidelines

| # | Management Guidelines | Implementation Status | Relevant to Current Situation |
|---|---|---|---|
| 1 | Management Goal: provide for diversified recreation opportunities (observation, photography, study, and limited harvest of adult rams). | Never codified | Yes Update & Approve |
| 2 | The San Gabriel's should be managed as a single population | Implemented | Yes |
| 3 | The population should be surveyed once annually | Implemented | Yes |
| 4 | De-classify as fully protected and as a sensitive species | Forest Service de-classified as sensitive. | Review current classification. |
| 5 | A population management plan should be considered (limited harvest) | Not Implemented | No |
| 6 | The current distribution and integrity of escape terrain should be maintained. | Not Implemented | Yes |
| 7 | Chaparral and oak vegetation associations should receive priority when vegetation manipulation is considered. | S. Fk. Lytle Creek, 2002. | Yes |
| 8 | Rural and urban recreation opportunities should not be provided | Implemented | Yes |
| 9 | Cross country travel in sheep habitat should not be encouraged | Unknown | Yes |
| 10 | New roads and trails should not pass within 100 m of a mineral lick. | Unknown | Yes |
| 11 | Ski facilities should not be operated commercially during summer | Not Implemented | Yes |
| 12 | Ski runs and ski ways should be planted with palatable forage | Not Implemented | Yes |
| 13 | The Forest Service should consider acquiring more flexibility and streamline the decision-making process in wilderness areas. | Not Implemented | Yes |
| 14 | No domestic sheep grazing allotments should be within 3.2 km of sheep habitat. | Implemented | Yes |
| 15 | Predator control should be instituted only if it is determined there is an unacceptable loss of sheep to predators. | Not Implemented | Yes |

Many of the guidelines have been implemented, they are relevant today, and should be continued in the future; these are described below. In some cases, some additional evaluation will be necessary to support current or proposed land uses.

- **Guideline 2**. The San Gabriel Mountain bighorn sheep population should be managed as a single population because it is isolated from all other populations.
- **Guideline 3**. The population has been surveyed almost every year, resulting in a comprehensive dataset that can be used to test hypotheses and develop adaptive management strategies. Completion of the surveys is also consistent with CFGC 4901 for planning and will provide the FS with information to meet its planning direction in NFMA regulations Section 219.20.
- **Guideline 7**. The SBNF burned approximately 500 acres in the South Fork of Lytle Creek in 2002.
- **Guidelines 8, 9, & 10**. The Forests have not developed any new recreation facilities in bighorn sheep habitat. Plans to build a trail in the South Fork of Lytle Creek have been abandoned. There is a mineral lick along Forest road 2N06, which provides access to a miner and cabin owners in Coldwater Canyon. If bighorn sheep use increases along 2N06, the effects of traffic and disturbance to sheep using the mineral lick should be carefully evaluated.
- **Guideline 14**. The Forest's Land and Resource Management Plans currently prohibit domestic sheep grazing within at least two miles of bighorn sheep habitat. Implementation of this recommendation will ensure that one critical source of diseases will not affect the bighorn sheep population.

Six guidelines, numbers 1, 6, 11, 12, 13, and 15 were not implemented; they are relevant to the current situation and should be implemented in the near future. Guideline 4 (delisting as a FS sensitive species) was implemented and it should be reconsidered, given the current situation. These guidelines are discussed in more detail below under Conservation Strategies.

## Conservation Strategies

The conservation strategies described below are based on the current status of the San Gabriel Mountain bighorn sheep population and the management guidelines that were developed in 1983.

### List the Population as a Sensitive Species

The Regional Forester maintains a list of sensitive species. Sensitive species require additional management attention because of viability concerns and the FS manages these species to ensure they do are not listed as threatened or endangered.

The San Gabriel Mountain bighorn sheep population should be placed back on Regional sensitive species list. The viability of the population is questionable and impacts on them should be carefully evaluated in environmental documents. As an example, a biological evaluation was

prepared for the Kratka Ridge ski area (RCA & Associates 1993). Bighorn sheep are known to occur in the area (Holl and Bleich 1983); however, they were not considered in the analysis. The Mount Waterman and Mt. Baldy ski areas currently allow summer use of their facilities. This is inconsistent with the guidelines developed in 1983. Additionally, summer use of Mt. Baldy ski area was the subject of intensive investigations that concluded use would have an adverse effect on bighorn sheep (Light and Weaver 1973).

**Prepare a Conservation Plan**

A conservation plan that is consistent with CDFG section 4901 and NFMA regulations section 219.20 should be prepared by an interagency group of biologists. The conservation plan should be adopted by CDFG and become the conservation agreement between the FS and USFWS that is incorporated into the revised Land and Resource Management Plans (NFMA regulations section 219.20) currently being prepared for the ANF and SBNF.

The conservation plan should clearly describe the goals and objectives for the population. Rather than emphasizing the goal of providing for diversified recreation opportunities identified as Guideline 1, in 1983, the current goals should emphasize preservation and restoration of the population.

Objectives should be established for the size and distribution of the population, habitat suitability, and permitted activities in bighorn sheep habitat. The conservation plan should include those guidelines from the 1983 report that are relevant to the current situation. The plan should identify specific implementation measures to meet the goals and objectives. Implementation measures should include thresholds that identify when implementation actions are initiated and how success of the measure will be determined, time frames, and responsible individuals. Monitoring, using adaptive management as a feedback mechanism, should be included in the plan. Three critical issues that need to be addressed in the conservation plan are mountain lion removal, habitat restoration, and habitat fragmentation.

**Mountain Lion Removal.** Mountain lion predation is hypothesized to have resulted in the dramatic decline of bighorn sheep that occurred between 1989 and 1995. The lack of recovery in the population suggests that predation continues to affect bighorn sheep in the San Gabriel Mountains.

**CFGC 4800-4809**. Mountain lions are a specially protected mammal under state law. In 1999, Assembly Bill 560 authorized the CDFG to take mountain lions that were an imminent threat to the survival of any threatened, endangered, candidate, or fully protected sheep species.

Bighorn sheep in the San Gabriel Mountains are a fully protected species; therefore, any mountain lion perceived to be a threat to these animals may be removed by CDFG (CFGC 4801).

Lions that are removed must be taken by the most effective means available; however, poison, leg-hold, metal-jawed traps, or snares may not be used (CFGC 4809).

Mountain lions have been removed from the Sierra Nevada, where they prey on endangered bighorn sheep and lion removal has been authorized in the recovery plan for bighorn sheep in the Peninsular Mountains (U. S. Fish and Wildlife Service 2000).

**Distribution and Abundance of Mountain Lions in Bighorn Sheep Habitat.** Little is known about the distribution and abundance of mountain lions in the San Gabriel Mountains because there have been no studies conducted on this population. Historically, the number of lions removed for bounties (n = 387) suggest that mountain lions were common in the San Gabriel Mountains. The large number of mountain lions removed from the western end of the San Bernardino Mountains and the eastern end of the San Gabriel Mountains (n = 110) by C. Hert and his extensive descriptions of capturing lions in the San Sevaine area suggest that this was a population source for mountain lions.

San Sevaine Flats is in the area used by the Cucamonga Peak group of bighorn sheep. During the 1988 survey it was noted that approximately 50% of sheep were not observed in Cucamonga Canyon, approximately 6-7 miles west of San Sevaine. Subsequent analysis of the survey data showed that bighorn sheep on most winter-spring ranges in the Cucamonga group declined substantially after 1988. Bighorn sheep in Mount San Antonio group did not decline substantially until after 1993 and sheep in the Iron Mountain and Twin Peaks groups declined substantially after 1995. The current decline in bighorn sheep suggests that the San Sevaine area may still be a population source of mountain lions.

**Effects of Mountain Lion Removal on Bighorn Sheep**. Current surveys indicate that adult survivorship of bighorn may still be affected by mountain lion predation. Predator management is a controversial subject; however, removal of some mountain lions may be necessary in the short-term, to preserve bighorn sheep in the San Gabriel Mountains.

A study in Canada demonstrated that the loss of a mountain lion known to prey on bighorn sheep reduced the rate of decline in that bighorn sheep population (Ross et al. 1997). Simulation modeling for the Peninsular Mountains indicated that removal of mountain lions for a short period of time effectively decreased the risk of extinction for small populations of bighorn sheep (Ernest et al. 2002). In the Peninsular Mountains, predator removal may be implemented when there are fewer than 15 adult ewes in designated recovery regions. Currently, there are fewer than 15 ewes in three of the four groups of bighorn in the San Gabriel Mountains (see Table 4).

The following steps should be considered when implementing a mountain lion removal project.

- Establish clear guidelines that identify when, where, and how a mountain lion will be removed;
- Obtain the data necessary to support the removal of the lions;
- Secure approval from CDFG;
- Ensure the removal is consistent with CFGC section 4809; and
- Monitor the response of the bighorn sheep population group to determine the effectiveness of the removal.

**Habitat Restoration.** Bighorn sheep winter-spring ranges are dominated by several vegetation types (Holl and Bleich 1983). Hardwood and conifer-hardwood habitats, dominated by interior or canyon live oak (*Quercus wislezenii and Q. chrysolepis*) and bigcone Douglas-fir (*Psuedotsuga macrocarpa*)-canyon live oak, are used substantially less than other habitats because they do not provide the diversity of forage species and the dense cover in these types inhibits the ability of bighorn sheep to visually detect predators. Chaparral habitat types are used year around by bighorn sheep. Browse species from chaparral provide over approximately 60% of the annual diet of bighorn sheep (Perry et al. 1987) and stands with less than 30% cover are preferred by bighorn sheep (Holl and Bleich 1983). The initial decline in the San Gabriel bighorn sheep population was associated with seral changes in chaparral that occurred as a result of wildland fires.

On steep, rocky sites the chaparral is dominated by a *Ceanothus*-birch leaf mountain mahogany (*Cercocarpus betuloides*) association. Less rocky sites, with better developed soils, are characterized by mixed chaparral, that may include chaparral whitehorn (*Ceanothus leucodermis*), chamise (*Adenostoma fasiculatum*), holly-leaf cherry (*Prunus ilicifolia*), and scrub oak (*Quercus dumosa*). California buckwheat (*Eriogonum fasciculatum*) and white sage (*Salvia apiana*) are also common species in this associations Pure stands of chamise are also present on these ranges; however, this association is not widely used by bighorn sheep.

**Distribution of Chaparral Habitat on Winter/Spring Ranges**. The distribution of chaparral on winter-spring ranges was calculated from the 1999 version of CALVEG, a statewide vegetation map. Chaparral comprises 58 % of the vegetation on winter-spring ranges (Table 6). Approximately 90% of the chaparral is greater than 20 years old on these ranges. Stands of mixed chaparral and chamise that are greater than 20 years old are avoided by bighorn sheep because the density of the vegetation restricts their ability to detect and avoid predators (Holl et al. 2002).

Figure 8a and b describes the changes in the cover of mixed chaparral in the Cattle Canyon winter-spring range. This area burned in 1975 and use by bighorn sheep area was described in Section 2 (see Table 3). In 1983, the shrub vegetation was widely spaced and large

Figure 8a. Cattle Canyon burn area, in 1983. The chaparral vegetation was sufficiently open that 219 groups of ewes were observed during the annual surveys, between 1979 and 1982.

Figure 8b. Cattle Canyon burn area, in 2002. The camera angle is different; however, note the large shrub in the upper right hand corner of both photographs. This is now low suitability bighorn sheep habitat because of the extensive amount of cover of the chaparral.

numbers of bighorn sheep were always observed in this area. The same area was photographed in 2002. The shrub cover has increased substantially, providing very low suitability habitat. Very few sheep have been observed in this area since 1998.

Changes in habitat suitability in associations of *Ceanothus*-birch leaf mountain mahogany, are not as great as those in mixed chaparral. For instance, a large portion of the San Gabriel Wilderness winter-spring range has not burned in over 45 years. It is hypothesized that associations of *Ceanothus*-birch leaf mountain mahogany supported approximately 160 bighorn sheep in 1976. The older stages of this habitat type are used by bighorn sheep because the vegetation does not achieve the same dense cover as mixed chaparral. As a result, it is a characteristic of high suitability habitat in the San Gabriel Mountains (Holl and Bleich 1983).

**Table 6.** Characteristics of winter-spring ranges within bighorn sheep groups in the San Gabriel Mountains.

| Group | Winter-Spring Ranges (ac) | Chaparral (ac) | Chaparral ≥ 20 years old (ac) | Chaparral ≥ 20 years old Wilderness (ac) |
|---|---|---|---|---|
| Cucamonga Peak | 7,214 | 3,509 | 2,968 | 435 |
| Mount San Antonio | 3,452 | 2,245 | 2,245 | 2,245 |
| Iron Mountain | 3,172 | 1,905 | 1,303 | 1,303 |
| Twin Peaks | 6,718 | 4,370 | 4,370 | 4,370 |
| Total | 20,556 | 12,029 | 10,886 | 9,090 |

Approximately 93% of bighorn sheep winter-spring ranges on the ANF in wilderness are characterized by chaparral that is greater than 20 years old. Approximately 15% of bighorn sheep winter-spring ranges on the SBNF in wilderness are characterized by chaparral that is greater than 20 years old. The California Wild Heritage Act of 2002 (S 2535) would add remaining habitat in the Middle Fork of Lytle Creek and all of the habitat in the South Fork of Lytle Creek winter-spring ranges to the Cucamonga Wilderness.

Limited access and steep rugged terrain limits the use of mechanical and hand treatments of vegetation in bighorn sheep winter-spring ranges. The only efficient vegetation management tool available is fire. Management direction for the use of fire is described the current ANF and SBNF Land and Resource Management Plans, federal wildland fire management policy, and wilderness plans.

**Land and Resource Management Plan Direction.** Current direction in the Land and Resource Management Plans do not allow the use of management ignited prescribed fires (prescribed burns) in designated wilderness. Therefore, under the current direction, there are no opportunities for planned habitat management on the ANF. Approximately 500 acres were burned on the SBNF in 2002 and there are other opportunities on that Forest because not all of the winter-spring ranges are in wilderness. The use of management ignited prescribed fire in

wilderness areas is being considered in the revised plans; however, the plans will not be approved until 2004.

**Federal Wildland Fire Management Policy**. After the disastrous fire season of 2000, the Federal Wildland Fire Management Policy (FWFMP) was reviewed and updated (www.nifc.gov/fire_policy). The current policy (Chapter 3) is clear that public safety is the first priority.

The FWFMP does recognize that:

- fire management activities will be used to achieve ecosystem sustainability;
- suppression of wildland fires will be based on ecological, social, and legal consequences of the fire; and
- wildland fire will be used to enhance resources and function in its natural role.

This policy direction provides some limited opportunities to use wildland fire to benefit resources, such as bighorn sheep habitat. When a wildland fire escapes initial attack, the FS is required to conduct a Wildland Fire Situation Analysis to develop objectives and suppression strategies. Based on fire fighter safety, resource values, and natural features the suppression strategy may be adjusted to allow fire to play its natural role in the environment.

**Wilderness Management.** Land management activities in designated wilderness areas on the SBNF are currently also governed by the Forest's Wilderness Management Plan. The Wilderness Management Plan will allow management ignited prescribed fires in wilderness to enhance wilderness values, such as bighorn sheep. The current draft of the wilderness legislation (S 2535) potentially affecting bighorn sheep habitat allows for:

". . . management activities to maintain or restore . . . wildlife populations and the habitats which support such populations . . . within wilderness areas designated by this Act, when consistent with relevant wilderness management plans. . ." (Section 102).

Therefore, if S 2535 is passed before the SBNF Land and Resource Management Plan is revised, prescribed burning could still occur in the Cucamonga Wilderness and its additions. The ANF does not have a current Wilderness Management Plan. As a result, no management ignited prescribed fires can occur in the Sheep Mountain or San Gabriel Wilderness until the ANF Land and Resource Management Plan is revised.

**Habitat Fragmentation.** Caltrans is currently evaluating reopening Highway 39, between Crystal Lake and Highway 2 (Angeles Crest Highway). Bighorn sheep are known to use this area and this area provides a corridor that allows movement between the Twin Peaks and Iron Mountain groups of bighorn sheep. Vehicle traffic would result in disturbance and

potentially direct mortality to bighorn sheep using this area. The loss of the corridor would isolate the Twin Peaks group from the rest of the groups of bighorn sheep and eliminate the transfer of genetic material between these groups. Given the current size of the Twin Peaks group, this segment of the population would be extirpated in the near future.

**Federal Listing the San Gabriel Mountain Bighorn Sheep as Threatened or Endangered**

The current viability of the San Gabriel Mountain bighorn sheep population is questionable and federal listing as a threatened or endangered species under the ESA is a conservation strategy. This section describes the criteria that must be considered if a petition to list this population is prepared for the U. S. Fish and Wildlife Service (USFWS).

**Distinct Vertebrate Population Segment** . Any species, subspecies, or distinct population segment of any vertebrate species is eligible for listing under the federal ESA (50 CFR 424.11). The USFWS has an established policy to recognize a distinct vertebrate segment (Federal Register 61:4722). A discrete population segment must satisfy one of the following conditions:

- separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behaviorial characters; or
- it is deliminated by international government boundaries within which there are significant differences in the management of the population.

Only the first criteria applies to the San Gabriel Mountain bighorn sheep population.

The San Gabriel Mountain sheep population is physically separated from all other populations of the same subspecies, as described in Section 2. Therefore, the probability of genetic exchange with another population is very low. There are currently no barriers to movement within the mountain range; therefore genetic exchange occurs between the four groups of bighorn sheep. There is some evidence, based on a comparison of skulls from ewes that the San Gabriel population is unique compared to other populations of Nelson's bighorn sheep (Wehausen and Ramey 1993). A larger sample size of skulls would be necessary to verify that the San Gabriel population is morphometrically different than other populations (Wehausen pers. com.).

There has been an evaluation of mitochondrial DNA (mtDNA) for 27 bighorn sheep populations in the southwest (Ramey 1995). Bighorn sheep from the San Gabriel Mountains have mtDNA haplotype A, the most common type found in the populations sampled. The data also indicates that there are genetically separate populations of bighorn sheep in the Transverse and Peninsular ranges.

In addition to being isolated from all other populations of bighorn sheep in southern California, this population is unique because:

- the population occurs in chaparral, a fire-dependent ecosystem, unlike most other desert bighorn sheep populations;
- it was used as the source of animals to reestablish bighorn sheep in other areas;
- the population is capable of being the largest population once again; and
- it is adjacent to the largest metropolitan area in California.

**Section 4 of the ESA**. Section 4(a)(1) of the ESA (16 U.S.C. 1533 [a] [1]) directs the USFWS that a species should be federally listed if it meets any of the criteria described below. A brief response is provided for each criterion.

- *The present or threatened destruction, modification, or curtailment of the species' habitat or range.*

Bighorn sheep winter-spring ranges in the San Gabriel Mountains are a fire-dependent ecosystem. The early seral stages provided by wildland fires increase the quantity and quality of habitat, resulting in population increases. Bighorn sheep were observed using areas that recently burned and the population decline that occurred from 1982-1988 was attributed to habitat changes associated with the maturation of chaparral vegetation that had burned between 1968 and 1975.

The following discussion of wildland fire on the ANF and SBNF is summarized from Stephenson and Calcarone (1999). Pre-European settlement fire return intervals in chaparral probably ranged from 50-80 years, which is similar to the current fire return intervals. There is general agreement that the number of ignitions on the National Forests has increased, particularly in the urban-wildland interface. However, active suppression, during less than extreme fire weather conditions, has effectively contained those fires. Studies indicate that the frequency of small fires has declined in southern California.

There is disagreement about the burning pattern of large wildland fires. One hypothesis states that suppression has reduced the number of frequent small fires, resulting in fewer but larger wildland fires. The other hypothesis states that large fires have always occurred in southern California.

The effective suppression of fires that are ignited during less than extreme fire weather has probably reduced the amount of early seral stages in bighorn sheep habitat. However, the frequency and extent of these disturbances are unknown. Suppression of these fires in mixed chaparral has probably had the greatest adverse effect. Early seral stages of mixed chaparral on steep slopes provides high suitability bighorn sheep habitat; whereas mixed chaparral

greater than 20 years old provides very low suitability habitat. Therefore, after this habitat association burns it increases the quantity and quality of available habitat. Associations of *Ceanothus*-birch leaf mountain mahogany do not achieve the same height or density of mixed chaparral associations. As a result, suppression of fires in *Ceanothus*-birch leaf mountain mahogany associations may not have the same adverse affect because bighorn sheep are currently using areas of this habitat type that have not burned in over 45 years.

Excessive fuel accumulations and extreme weather conditions will always result in large fires on the ANF and SBNF. These large fires are currently the primary mechanism to modify bighorn sheep habitat in the San Gabriel Mountains.

Reopening of Highway 39 may result in the loss of the only movement corridor connecting the Twin Peaks and Iron Mountain groups of bighorn sheep. This would result in isolation of the Twin Peaks group and extirpation of that group from the mountain range.

- *Overutilization for commercial, recreational, scientific, or educational purposes.*

Bighorn sheep in the San Gabriel Mountains are a fully protected species; therefore, they are not subject to overutilization from regulated harvesting. Limited poaching has occurred in the mountain range; however, it is not affected the population.

Disturbance from recreationists can result in the avoidance of key areas by bighorn sheep, particularly during spring and summer when ewes with lambs are more sensitive to disturbance (Hicks and Elder 1979, Hamilton et al. 1982, Deforge 1980, Holl and Bleich 1983). Light and Weaver (1973) concluded that summer use of ski areas resulted in habitat loss. Two ski areas are currently permitted to use lift facilities to move people onto summer ranges. It is unknown what affect this activity may have on bighorn sheep that use those areas.

From 1983-1987, 73 bighorn sheep were captured for relocation. The relocation of bighorn sheep from the South Fork of Lytle Creek to Prairie Fork on the ANF was not successful. In 1985 and 1987, 42 bighorn sheep were relocated from Cattle Canyon on the ANF to the Los Padres N.F. Following removal of sheep from the South Fork of Lytle Creek in 1983, the mean $\pm$ s.e. number of sheep counted was $37 \pm 6.4$ from 1983-1988. The number counted declined to 24 in 1989 and continued to decline after that. Following the removal of sheep from Cattle Canyon there were $56 \pm 14.2$ from 1985-1992. The number counted declined to 26 in 1993. The substantial declines in these groups of bighorn sheep occurred at least six years after the removal for relocation and it is concluded that removal of sheep did not contribute to the current population levels.

There are no relocations planned and any future removal of bighorn sheep from this mountain range would only occur after there has been a substantial increase in the population.

- *Disease or predation*

There is no evidence that disease has contributed to the substantial decline in the number of bighorn sheep in the San Gabriel Mountains. The ANF and SBNF have established forest policies prohibiting domestic sheep from grazing within at least two miles of bighorn sheep habitat. This policy will eliminate a source of diseases that have affected several other bighorn sheep populations.

Mountain lion predation has been hypothesized to contribute to the recent decline of bighorn sheep in the San Gabriel Mountains. Although lamb recruitment rates appear to be sufficient, the lack of increase in the number of adult animals indicates that predation is preventing the population from increasing above the current level.

- *The inadequacy of existing regulatory mechanisms*

All populations of Nelson's bighorn sheep are fully protected, unless designated by the State Fish and Game Commission (CFGC 4901). Therefore, individual animals, or parts, may not be taken or possessed, unless it is authorized for scientific research (CFGC 4700). This protection does not include the loss or modification of habitat or disturbance, which may affect the behavior of bighorn sheep.

Bighorn sheep are not listed as a sensitive species by the FS. As a result, they are not required to be considered in biological evaluations that are prepared during the evaluation of projects that may affect their habitat or behavior. As a result, activities that may have an adverse impact on bighorn sheep habitat or their behavior may be approved without evaluating the impacts.

Current policy in the Forest's Land and Resource Management Plans do not allow the use of management ignited prescribed fire in designated wilderness. However, the approved Wilderness Plan on the SBNF apprears to allow planned ignitions in wilderness. All of the winter-spring ranges on the ANF are in designated wilderness areas. As a result no management ignited prescribed fires can be considered on the ANF until at least 2004.

- *Other natural or manmade factors affecting the species survival*

At the national level, fuel management projects that occur in the wildland-urban interface receive the highest priority for funding. Funding for fuels management projects on the National Forests has increased substantially, particularly to protect communities. Funding for projects

that restore wildlife habitat are a lower priority. However, given the proximity of bighorn sheep winter-spring ranges to foothill communities, it would appear these projects could receive high priority funding.

Federal funding for fuel management projects in southern California is disproportionately low. Last year, the Lassen and Plumas National Forests received $18.7 million for fuel reduction projects, while the SBNF received $2.1 million. The amount of funding affects the Forest's ability to conduct fuels management projects that provide benefits for fire-dependent species, such as bighorn sheep in the San Gabriel Mountains. Last year the Lassen and Plumas National Forests treated over 45,000 acres, compared to less than 4,000 acres treated on the ANF.

The disproportionate funding between the Lassen and Plumas National Forest and the southern California Forests may occur because of regional funding priorities. The Quincy Library Group Pilot Project is a congressionally-mandated program that is being implemented on those Forests. Congressionally-mandated programs are generally funded before other programs. Future funding for fuels management in southern California may not improve in the near future because another congressionally-mandated project, the Granite Stewardship Project is scheduled to start on the Stanislaus National Forest in 2003.

**Evaluation of Conservation Efforts**. The ESA also requires the USFWS to consider any State or local laws, regulations, ordinances, programs, or other conservation measures that affect a species status (section 4(b)(1)(A). The CDFG, in conjunction with the FS and Los Angeles Fish and Game Commission have provided the funding and resources to conduct the annual survey. That information has provided the basis for the current analysis and would be absolutely necessary to prepare a new conservation strategy and management plan. The State legislature modified the CFGC in 1999 to authorize the removal of mountain lions that may be threat to a fully protected species.

**Conclusion**. Based on this evaluation, the San Gabriel Mountain bighorn sheep population is a distinct population segment that meets at least two of the criteria for listing, habitat modification and predation. Current policies affecting burning on the ANF contribute to the constraints of that Forest to restore habitat. The availability of federal funding for habitat restoration projects also affects the Forests' ability to restore habitat.

**State Listing as Threatened or Endangered**

Listing this population under the California ESA is another strategy. The CFGC (section 2070-2079) describes the critera required to list a species under the state ESA. However, listing under the CESA would not impact actions that may affect habitat on federal land. Additionally, the CESA would not provide any additional protection for individual animals. A permit may be issued for take, if it is associated with legitimate pursuits; however, as a fully protected species, a take permit may only be issued for scientific purposes.

## Management Recommendations

The following recommendations are based on the current status of the San Gabriel Mountain bighorn sheep population, ecological factors that affect the population, regulatory constraints and opportunities, and funding mechanisms.

**Immediately list the population as a sensitive species**. The FS should immediately list the population as sensitive. Re-listing the population will ensure that impacts on bighorn sheep are thoroughly considered in all biological evaluations prepared for projects in bighorn sheep habitat. Additionally, listing as a sensitive species would ensure that bighorn sheep are considered in Wildland Fire Situation Analyses, that may result in some habitat restoration during unplanned ignitions.

**Prepare a conservation plan**. An interagency group of biologists should prepare a conservation plan that can be implemented within one year. This plan should be adopted by CDFG and serve as a conservation agreement between FS and USFWS to ensure the population is not federally listed.

**Initiate a study of mountain lions.** CDFG should immediately initiate a study to evaluate the occurrence of mountain lions in bighorn sheep habitat in the San Gabriel Mountains.

**Obtain support for a congressionally-mandated fuels management project in the San Gabriel Mountains**. A broad-based coalition of interest groups (e.g., local community leaders, environmentalists, watershed councils, sportsmen's groups) should prepare and obtain support for a pilot project in the San Gabriel Mountains that reduces fuel hazards and restores wildlife habitat. A congressionally-mandated project would increase the probability of funding for these projects.

**List the San Gabriel Mountain bighorn sheep population under the ESA**. If a conservation plan cannot be implemented within one year, the population should be federally listed as threatened or endangered. Listing the population will ensure that a recovery plan is developed and implemented to preserve and restore the population. Listing the population will increase coordination between the FS and USFWS because all activities proposed in bighorn sheep habitat will be reviewed to ensure the activities do not result in take, as defined in the ESA.

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