Mountain lion and human activity in California: testing speculations

Steven G. Torres, Terry M. Mansfield, Janet E. Foley, Thomas Lupo, and Amy Brinkhaus

Abstract We compiled and analyzed 24 years (1972–1995) of verified incidents of mountain lions killing domestic animals (n = 2,663) to examine trend, distribution, and types of conflicts in California. To model the relationships between mountain lion depredation and various human activity and habitat factors, we tested 2 predictive models. Domestic sheep depredation in counties was significantly (P < 0.05) related to amount of suitable mountain lion habitat. We hypothesize that increasing domestic sheep depredation may reflect regional increases in the distribution and abundance of mountain lions. A regression model of percent pet depredation indicated a significant (P < 0.05) association with average annual new house development (1979–1993). Counties with significant pet depredation are in the same regions where public safety problems have occurred and reflect a radiation of human activity into mountain lion habitat. Mountain lion depredation data may be a useful index of regional mountain lion activity. Livestock and pet depredation problems are increasing in different regions of the state for different reasons; pet depredations are increasing the most rapidly. Pet depredation may be a useful indicator of mountain lion proximity to humans.

Key words California, depredation, development, domestic sheep, human activity, livestock, mountain lion, pets, Puma concolor

Mountain lion (Puma concolor) management in California has a political history (Mansfield and Weaver 1989). Lions were bountied from 1907 to 1963, and state records indicate that 12,461 mountain lions were killed during that 57-year period. During 1963–1968, lions were managed as a nongame and nonprotected mammal; take was not regulated, and no state records were kept. From 1969 until early 1972, mountain lions were classified game mammals, but only 1 complete, regulated hunting season (1970–1971) occurred during this period. The 1971–1972 hunting season was shortened by a moratorium on mountain lion hunting that began in February 1972. During this hunting program 4,953 tags were sold and 118 mountain lions were killed. During the moratorium, the California Department of Fish

View of Los Angeles county from San Gabriel Mountains, California. Photo by Steve Torres.

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and Game (Department) initiated radiotelemetry studies that provided some of the first detailed home-range, distribution, and density information for several regions of the state (Sitton and Weaver 1977). Subsequently, the Department prepared a management plan for mountain lions and provided the first empirical estimates of statewide mountain lion numbers. In 1986, mountain lions were again classified as game mammals. However, Department recommendations for regulated mountain lion hunts (190 tags distributed across 4 zones) were challenged in court during 1987 and 1988. A ballot initiative (Proposition 117) designating the mountain lion as a "specially protected mammal" was passed into law in 1990. A ballot measure (Proposition 197) that would have modified current law regarding mountain lion management failed in March of 1996. This failure was a result of the public's concern that the change in law may allow mountain lion hunting. Mountain lion hunting has not occurred in California since 1972.

During the last 24 years, the Department has recorded a substantial increase in human–mountain lion conflicts. In 1973, 21 mountain lion depredation incidents (property damage associated with killing of domestic livestock and pets) were verified for which permits were issued to kill offending lions. In contrast, the Department issued 331 permits for verified incidents in 1995. Additionally, mountain lion attacks on people, although rare, are becoming more frequent. During 1910–1985, there were no verified mountain lion attacks on humans in California. Since 1986, there have been 9 verified attacks on humans, with 2 fatal attacks on adult women in 1994. These attacks, beginning in 1986, may reflect a threshold at which increases in human and mountain lion activity predispose conflicts.

In this paper, we consider mountain lion management in California as a case study. Mountain lion hunting has not occurred in 24 years, and circumstantial evidence suggests lions have become more numerous and extended their range over that period. In addition, the rapidly increasing human population and changing landscape may be related to the observed increasing depredation and public safety problems, and public opinion is polarized regarding possible management solutions. Some people speculate that mountain lion populations are increasing dramatically statewide and pose a threat to their lives and property, while others believe that increases in human population and activity are solely responsible for the problems. The potential error in either of these speculations is that (1) these generalizations are made in a statewide context, yet they probably vary regionally; and (2) increasing human activity and changing mountain lion demographics may not operate independently toward influencing the observed conflicts.

Despite these contrasting views, the public recognizes mountain lions as an important part of California's wildlife heritage. There appears to be a common desire that potential management solutions should be biologically sound to ensure the survival and viability of mountain lion populations while promoting public safety. Unfortunately, mountain lion management policy has been primarily influenced by polarized advocate groups in California.

We will attempt to clarify relationships between mountain lion activity and public safety problems by comparing mountain lion depredation incidents to various human activities and environmental factors. By examining changes in human popula-

Dog killed by mountain lion, San Diego County. Photo by Bob Turner, courtesy of California Department of Fish and Game.
tion size, recreational activity, and land-use (statewide and regionally), we attempt to characterize rare events such as attacks and identify areas predisposed to problems. We test some simple models and popular "speculations" related to mountain lion and human activity, and habitat factors. Since most of our analyses are associative, cause-and-effect relationships may remain unclear.

The objectives of our analyses include the following: (1) describe mountain lion depredation policy, data, and potential biases; (2) characterize mountain lion and human activity temporally and spatially; (3) examine other covariates (habitat, land-use); and (4) test predictive models to identify and describe problem areas.

**Methods and data**

**Depredation data**

Mountain lion depredation policy, regulations, and data collection procedures in California have been consistent over the last 24 years. As part of this policy, depredation permits and records have been kept by the Department since 1972. In 1972, the state established a mountain lion depredation policy that required Departmental verification of property damage. After verification, a permit was issued (under strict guidelines) to the property owner to kill the offending mountain lion. Upon issuance, Department staff must send a copy of the depredation permit to Department headquarters in Sacramento. Additionally, the carcass of any mountain lion killed must be returned to the Department. This verification and permitting system created, albeit fortuitously, a valuable index of mountain lion activity throughout the state. These records (2,663 through 1995) are maintained in a dBASE IV (Borland International, Inc., Scotts Valley, Calif.) database in Department headquarters. They include the date of issuance, permit number, county, reason of issuance, and other variables for all reported and verified depredations attributable to mountain lions. For our analyses, depredation data utilize all records of verified incidents where permits have been issued, and our spatial level of resolution is the county. In this paper, we refer to depredation incidents that result in the issuance of a permit as "incidents," and only these verified depredation reports are used in our analyses.

**Mountain lion and human activity in California**

Mountain lion depredation data, totaled by year for each county, were treated as the primary response variable for which mountain lion activity was assessed. These data were then divided into an early and recent period to evaluate changes in types of domestic animals killed. The second derivative of the depredation curve was used for delimiting the early and late periods. Given the increasing pattern of depredation incidents, the point at which the second derivative is closest to zero expresses the point at which the rate of change is greatest.

We analyzed a subset of total depredation data describing lion predation on pets to determine usefulness of the data in defining proximity of lions to humans. These pet data are expressed as a percentage of total depredations reported from each county, for each year, to qualitatively represent regions where this is the dominant type of conflict. We used data from necropsies of depredating mountain lions to document their sex and age for comparison with data from mountain lions involved in public safety incidents.

We summarized human activity factors by county and time period for a general associative analysis with lion depredation data. Human activity factors considered were population size, development (numbers of new housing units/yr), recreation (person-days at state parks), and livestock. As appropriate, we corrected these variables by area (for density estimates) to make intercounty comparisons. Population, housing, and livestock data were obtained from the "California Statistical Abstract" (Calif. Dep. Finance 1995) for each year. Recreation data were obtained from the Accounting Office of the California Department of Parks and Recreation (CDPR) in Sacramento. CDPR summarizes attendance data for approximately 268 parks throughout California.

We considered precipitation and drought factors for their potential role in influencing mountain lion activity. However, earlier analyses of incident data (J. E. Foley, P. Foley, and S. G. Torres, Mountain lion depredation in California, 1972–1994, Calif. Dep. Fish and Game, Sacramento, unpubl. rep., 1996) did not find any significant associations. Deer survey data were not included in this statewide analysis because many "urban fringe" areas of the state, critical for our approach, are not represented in the surveys.

**Spatial properties of mountain lion and human activity**

We characterized regional depredation activity by examining number of reports and rate of change for each county (1972–1994). To establish rates of change, we computed slope coefficients using linear regression of the relation between depredation incidents and time (yr), for each county. We examined
depredation activity by plotting average number of incidents by the linear trend (regression slope coefficient) for each county. Depredation activity was classified into 3 categories based on the ranking of the product of average number and linear trend of reported incidents as follows: high = ≥75 percentile; moderate = 50-74; low = <50. Data on human activity were similarly categorized using percentiles for spatial comparisons with depredation data.

**Habitat suitability**

We used a geographic information system to overlay the known range of mountain lions on the CALVEG (U.S. For. Serv., Calif. Dep. For.; Parker and Matyas 1980) vegetative association database. This geographic subset of 73 dominant vegetation types was then cross-referenced to 39 California Wildlife Habitat Relationship (CWHR; Airola 1988) system vegetative types for estimating the area of moderately to highly suitable vegetative associations within mountain lion range within counties. The CWHR system provides a predictive model that allows us to assess the relative value of habitat types for mountain lions. Our county habitat summaries do not give greater weight to areas known to be optimal, but rather conservatively total the area estimated to be moderately to highly suitable mountain lion habitat.

**Associations and model testing: the role of other factors**

We assembled estimates of suitable habitat (km²), human population, housing development (number of new houses), recreation (person-days), and livestock numbers for counties and analyzed them for spatial and temporal associations. To model the relationships between depredation and these factors, we tested 2 predictive models. First, we used stepwise linear regression of county estimates of average domestic sheep depredation (1985-1992, dependent variable) on domestic sheep numbers (averaged over 8 yrs, 1985-1992), average domestic sheep density (1985-1992), human population and density (1993), average annual housing units built (1979-1993), new housing-unit density, average annual recreational visitor days (1986-1993), per capita recreation (annual attendance/human numbers), linear trend in recreational activity (1986-1993), and our estimate of area of suitable mountain lion habitat. This model served as a control to contrast with a regression of pet depredation and further served as a test of the integrity of these depredation data. Second, we regressed the same county statistics of pet depredation (expressed as a percent of total depredations, 1972-1994) on human-activity factors and suitable habitat. The arcsin square root transformation was made on percent pets, as appropriate for a proportional dependent variable (Neter et al. 1985). Multicollinearity of independent variables was controlled by using stepwise linear regression with statistical tolerance values set at 0.01. Cook's distance (Cook and Weisberg 1982), a regression diagnostic, was used to identify outliers and influential data.

SAS (SAS Inst., Inc. 1988) and BMDP/PC (BMDP Stat. Software, Inc. 1992) statistical software were used for univariate statistics, exploratory linear regression models, and regression diagnostics. ARC/INFO (ESRI, Redlands, Calif.) software was used for habitat analysis and presentation.

**Results**

During 1972-1995, depredation incidents by mountain lions in California increased from 4 in 1972 to 331 in 1995 (Fig. 1), and over the last 10 years attacks by mountain lions on humans increased in frequency in California (Table 1); we recorded ≥1 attack/year in the last 4 years and 9 attacks since 1986. Concomitantly, the human population increased from approximately 20 to 32 million people. The development of new single-unit houses increased from 60,000 units/year in 1981 to a peak of 163,000 units in 1989 and has resulted in further encroachment into wildlife habitat. However, statewide numbers of domestic sheep have declined 29% from 1,014,000 in 1972 to 716,000 in 1992. Cattle have declined 7% from 4,854,000 in 1976 to 4,500,000 in 1992. From 1986 to 1994 recreational activity shows a stable to declining trend with visitorship estimated at approximately 66 million person-days in 1986 and 1993. A peak of park visitorship occurred in 1990 with 77,450,000 person-days reported.

We examined temporal associations in the depredation data by dividing the time series at 1984 (first derivative greatest), after which approximately 78% of the depredation problems occurred. Depredation permits were primarily issued for domestic sheep (≥50%), goats (17-19%), and cattle (14-18%; Fig. 2). However, only the changes in percentage of permits issued for pets ($\chi^2 = 11.76, 1 \text{ df}, P = 0.006, n = 148$), and cattle ($\chi^2 = 3.88, 1 \text{ df}, P = 0.049, n = 341$) were statistically significant ($P < 0.05$) between time periods.

Sex ratio data of mountain lions killed in association with public safety problems and depredation are shown in Figure 3. Combining records of mountain lion attacks from North America (Beier 1991) and California (Table 1) show a balanced to slight female bias, with only 46.2% male lions associated with these conflicts ($n = 39$). This sex ratio was not significantly dif-
Table 1. Verified mountain lion attacks on humans in California, 1890–1995

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>County</th>
<th>Type</th>
<th>Victim age</th>
<th>Sex</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun. 1890</td>
<td>Quartz Valley</td>
<td>Siskiyou</td>
<td>Fatal</td>
<td>7</td>
<td>M</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Jul. 1909</td>
<td>Morgan Hill</td>
<td>Santa Clara</td>
<td>Fatalb</td>
<td>10</td>
<td>M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar. 1986</td>
<td>Caspers County Park</td>
<td>Orange</td>
<td>Nonfatal</td>
<td>5</td>
<td>F</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>Oct. 1986</td>
<td>Caspers County Park</td>
<td>Orange</td>
<td>Nonfatal</td>
<td>6</td>
<td>M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar. 1992</td>
<td>Cuyamaca Rancho State Park</td>
<td>Santa Barbara</td>
<td>Nonfatal</td>
<td>9</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Sept. 1993</td>
<td>Cuyamaca Rancho State Park</td>
<td>San Diego</td>
<td>Nonfatal</td>
<td>10</td>
<td>F</td>
<td>1–2</td>
<td>F</td>
</tr>
<tr>
<td>Apr. 1994</td>
<td>Auburn State Rec. Area</td>
<td>El Dorado</td>
<td>Fatal</td>
<td>40</td>
<td>F</td>
<td>2–3</td>
<td>F</td>
</tr>
<tr>
<td>Aug. 1994</td>
<td>Dos Rios (remote)</td>
<td>Mendocino</td>
<td>NonfatalF</td>
<td>50's</td>
<td>M</td>
<td>2</td>
<td>F</td>
</tr>
<tr>
<td>Dec. 1994</td>
<td>Cuyamaca Rancho State Park</td>
<td>San Diego</td>
<td>Fatal</td>
<td>56</td>
<td>F</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Mar. 1995</td>
<td>Angeles National Forest</td>
<td>Los Angeles</td>
<td>Nonfatal</td>
<td>28</td>
<td>M</td>
<td>A</td>
<td>F</td>
</tr>
</tbody>
</table>

* Ages recorded in years. Adult mountain lions (≥3 years) are noted as A.

b Fatalities diagnosed due to rabies.

c Mountain lion confirmed to have rabies.
Percent of total permit issuance

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td>1.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Equids</td>
<td>3.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Pets</td>
<td>5.2</td>
<td>7.2</td>
</tr>
<tr>
<td>Cattle</td>
<td>7.7</td>
<td>13.8</td>
</tr>
<tr>
<td>Goats</td>
<td>19.1</td>
<td>17.2</td>
</tr>
<tr>
<td>Sheep</td>
<td>56.8</td>
<td>54.6</td>
</tr>
</tbody>
</table>

Fig. 2. Permit issuance (% of total) for types of animals killed by mountain lions between 1972–1984 and 1985–1995, California.

tat as the only statistically significantly ($P < 0.05$, $R^2 = 0.27$) independent variable. However, the statistical significance of this relation appeared to be driven by a few statistically influential counties (Fig. 8). Cook's distance (Cook and Weisberg 1982) identified Mendocino, Humboldt, and Siskiyou counties as most influential. The regression model of percentage pet depredation (dependent variable) identified average annual new house development (1979–1993) as the only significant ($P < 0.05$, $R^2 = 0.44$) factor, and was highly influenced by Los Angeles, Orange, Riverside, and San Diego counties (Fig. 9).

**Discussion**

**Depredation data**

Incidents of mountain lions killing livestock and pets increased from 1972 through 1995. However, the number of permits issued (incidents) appeared to plateau from 1989 through 1993 (5 yrs) when approximately 180–200 permits/year were issued. In 1994, a year in which 2 adult women were killed in separate attacks and 2 more adults were injured in 1 attack, the requests for depredation permits increased 73%. This increase likely does not reflect simply an increase in mountain lion ac-

Fig. 3. Percent male mountain lions associated with type of conflict (1972–1995), California.

Fig. 4. Average number by trend (regression slope coefficient) of depredations by county (1972–1994), California.

Depredation Human density

Fig. 5. Depredation in relation to human density and development (by county). Categories represent percentiles as follows: level 1 = >75, level 2 = 50–74, level 3 = <75 percentile. (A) Total depredation and human population density and (B) pet depredation and housing development.
Mountain lions in California • Torres et al. 457

tivity, but rather represents a change in request for permits due to public attention and concern. Indeed, 1995 permit issuance was very similar to 1994 (328 permits) and further suggests that mountain lion activity may be at the 1989–1993 level. Potential biases associated with these depredation data include underreporting (reporting compliance), overreporting (misidentification of mountain lion kill), and changes in permit requests for verified incidents (1994, 1995). Given the county support services such as Animal Damage Control (ADC), and the general difficulty in taking depredating mountain lions, we believe the reporting biases to be consistent and minimal from 1972 to 1993. However, we believe that increased public attention increased permit requests and issuance in 1994 and 1995. Interpreted in the appropriate context, depredation data are a valuable long-term series of data for identifying changes in regional mountain lion activity in California.

**Temporal and spatial properties of mountain lion and human activity**

California has changed dramatically over the last 24 years. The human population has increased to 32 mil-
Although these changes may be characteristic of urbanization, these statewide summaries do not represent regional changes within California, and any interpretation of their association with observed mountain lion conflicts are limited. Unfortunately, this is the level at which speculation regarding associations and potential solutions has translated into management policy.

Depredation incidents have also increased dramatically over the last 24 years and these problems occur in particular regions of the state. We observed concentrations of depredation in the northwest and north coastal counties, the east and west slopes of the central Sierra Nevada, and the central coast counties. These counties were primary contributors to the observed increase in depredation incidents and were not associated (spatially) with areas of higher human density. On the other hand, pet depredations (by % of total) occurred more frequently in counties with fewer total depredation problems, and were more coincident with areas of higher human numbers. Thus, different types of depredation problems occurred in different geographic areas.

Depredation permits were issued primarily (86–94%) for livestock during both time periods (1972–1984, 1985–1995). Sheep were the most frequently killed domestic animal, and for this reason we selected these data for our subsequent control model to test for general associations. Incidents of mountain lions killing pets increased significantly, while cattle depredations significantly decreased, between time periods. Permit issuance for domestic animals such as pets, horses, and birds that typically occur closer to human residences, all proportionately increased between time periods. Although these increases do not singularly account for the continued rise in depredation problems, they do represent a “proximity to humans” factor that relates to increasing human activity and development in lion habitat. Different from livestock depredation, pets are generally killed near human residences. Therefore, at least part of the increase in depredation permits is due to expanding human populations.

Sex and ages of mountain lions associated with depredation incidents and public safety conflicts were compared to validate similarities and differences between the types of conflicts. The majority (65.0%) of livestock depredations are made by male mountain lions, which is significantly different from the 44.7% male lions associated with killing pets. Further, this percentage (44.7%) was similar to that observed for lions killed in association with public safety problems (46.2% male; Beier 1991; Table 1). Similar sex ratios were observed for mountain lions associated with public safety (45% male) and livestock depredations (80% male) in Montana (Aune 1991). Although male mountain lions are known to have larger home ranges (Seidensticker et al. 1973, Pali et al. 1988, Hopkins 1989, Beier and Barrett 1993) that may provide more opportunities to encounter livestock, this logic does not explain the relatively lower encounter rate of male lions killed in association with pet or human conflicts. The sex ratio of lions not associated with depredation has been shown to be relatively balanced (1:1; M:F) in Colorado (Anderson 1983) and New Mexico (Sweanor 1990). However, Beier and Barrett (1993) suggested a much lower proportion of males in a population of lions in fragmented habitat of southern California, where vehicles were a primary mortality factor. If home-range size affects depredation, we can speculate that the observed balanced to slight female bias in the sex ratio of mountain lions associated with attacks on humans and pet depredations would result if male mountain lions have lower survivorship (i.e., vehicle mortality) in areas of higher human activity. However, the factors influencing sex ratios in these circumstances remain uncertain, and they are also likely related to prey size and the demographics of the respective lion population. Nonetheless, the sex of mountain lions associated with pet depredations shows closer similarity to public safety problems than livestock depredations. This relationship further validates the similarities between the occurrence of pet depredation and human safety problems.

Beier (1991) reviewed all reported mountain lion attacks in North America through 1990. Although his analysis provided valuable insight into factors such as human age, size, and response behavior, critical information related to the demographics of the associated mountain lion populations were not available. Adequate mountain lion demographic data remain unavailable for most regions of California. We observed that approximately 53.2% of depredations were made by subadult (<2 yrs) mountain lions, and there were no detectable age differences in lions associated with livestock or pet depredation. However, this percentage is less than the 61.3% subadults associated with attacks in the United States and Canada (Beier 1991). Since 1990, only 33.3% of lions killed in association with attacks were ≤2 years old in California, although the sample size is small (n = 6). This subadult percentage may simply represent the distribution of ages in the associated mountain lion populations. Given
the problematic accuracy of age data and the lack of supporting demographic data, we are unable to make any inferences regarding the influence of age factors on depredations or public safety.

Because there are too few public safety incidents for statistical analysis, we used the information on pet depredation to examine relationships with human activity and identify potential problem areas. Potential biases for pet depredation data mainly concern underreporting due to the uncertainty about the cause of a pet’s death or disappearance, and reluctance of pet owners to request a depredation permit. Therefore, the reports received and associations derived more conservatively represent urban-fringe areas than areas of higher human densities.

**Testing speculations**

In the first regression model which predicted domestic sheep depredation, our estimate of suitable mountain lion habitat was the only significant factor. The significance of this relationship is statistically influenced by Humboldt, Mendocino, and Siskiyou counties. Although the relationship is weak ($R^2 = 0.27$), it is meaningful qualitatively because counties that occur in high depredation activity areas (Humboldt, Mendocino) also have large amounts of estimated lion habitat. However, Shasta and Siskiyou counties had similar amounts of lion habitat, yet much fewer average domestic sheep depredations. Although numbers (or densities) of domestic sheep did not significantly help predict sheep depredations in our model, the density of sheep does appear to influence the observed relation in that Humboldt (1.95 sheep/km$^2$) and Mendocino (2.63 sheep/km$^2$) counties had higher densities of domestic sheep than Siskiyou (0.43 sheep/km$^2$). Therefore, the relative distinctions between these counties may be explained, in part, by density of domestic prey. We hypothesize that there are regional differences in lion distribution and density that may be related to differences in native prey. However, both domestic sheep numbers in Humboldt and Mendocino counties have declined dramatically, 42% and 36% respectively, since 1972. Therefore, increases in depredation since 1972 cannot be explained by numbers (or density) of sheep. Domestic sheep depredations are increasing in areas with suitable mountain lion habitat and may reflect regional increases in the distribution and abundance of mountain lions in northwestern California and the Sierra Nevada. However, this hypothesis needs to be tested by considering relative changes in the abundance of native prey.

In our second regression model of percentage pet depredation, only average annual new house development (1979–1993) was a significant factor. The significance of the relationship was influenced by Los Angeles, Orange, Riverside, and San Diego counties. As with sheep depredation this relation is important qualitatively, because these counties represent the same regions where public safety problems have predominantly occurred, and they most exemplify the radiation of human activity into mountain lion habitat.

These analyses illustrate that depredation data, if collected in a systematic way, have biological integrity that may be useful as an index of mountain lion activity. In California, livestock and pet depredation problems are occurring in different regions for different reasons. Furthermore, depredation incidents are increasing in several regions of the state, with pet depredations changing most. We believe pet depredation may be a useful indicator of mountain lion proximity to humans and the impacts of human development. Increased pet depredation may be a manifestation of habitat fragmentation and may emphasize the need to protect large blocks of intact habitat and movement corridors (Beier 1993, Tilman et al. 1994). Therefore, depredation reports help identify problem areas where management actions, such as education and habitat protection, can be focused. Essential to maintaining the integrity of depredation permits as an index of mountain lion activity is continued standardized procedures for issuance, verification, and compliance.

**Management and conservation implications**

There is speculation that the prohibition of mountain lion hunting since early 1972 has resulted in an increased number of mountain lions and dispersal of lions into areas of human activity. Conversely, there is speculation that the dramatic increase in the human population of California over this period has itself resulted in the observed increase in conflicts. Unfortunately, neither of these generalizations consider the regional diversity of lion habitat, prey availability, and human impacts. Our analyses indicate that observed conflicts between mountain lions and humans vary regionally for different reasons. Therefore, management agencies should adopt a regional approach toward wildlife conservation that considers the differing status of mountain lion populations and the feasibility of potential management activities.

Management goals for mountain lions in California include: (1) maintaining viable populations of mountain lions; (2) minimizing conflicts related to public safety, property damage, and other wildlife; (3) protecting important habitats; (4) recognizing their ecological role and value; (5) monitoring populations and conducting research; and (6) improving public awareness. There-
fore management solutions should be biologically motivated and directed to ensure the survival and viability of mountain lion populations while minimizing conflicts. This will require appropriate funding for population monitoring and research, which has not been available.

Managing a large predator in a state like California, with its diverse wildlife and wildlife habitats, rapidly changing land-use patterns, and shifting public opinion, is a profound challenge. Because we expect human-mountain lion conflicts to continue, the challenge will be to educate the public, to establish flexible policies, and to conduct research that will optimize our efforts to ensure the long-term survival of this species.

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Literature cited


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