ARIZONA GAME AND FISH DEPARTMENT

MOUNTAIN LION AND BEAR CONSERVATION STRATEGIES REPORT

January 14, 2009

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MOUNTAIN LION AND BEAR CONSERVATION STRATEGIES REPORT

This report was prepared to address a goal provided to the Director of the Arizona Game and Fish Department by the Arizona Game and Fish Commission at its meeting on May 1, 2008. The Department conducted a literature review, gathered comparative data from other states, and prepared a series of strategies that may be used to address management issues for mountain lion and bear in Arizona. The Commission will be briefed on this report at their March 5–6, 2009 meeting. The Commission will take no action on this briefing. All strategies presented in this report will require additional evaluation, and any hunting changes will require future action by the Commission in a public session.

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EXECUTIVE SUMMARY

This report was prepared by wildlife scientists and managers, including two contributors not employed by the Arizona Game and Fish Department (Department). This report reviews data available in Department files, peer-reviewed published literature, and conservation plans and strategies from other western states. The summaries and recommendations listed at the end of each strategy section are based on the best available information, supported by science, and are considered reasonable and cost effective.

This report examines several aspects of conservation and management for both mountain lions (*Puma concolor*) and black bears (*Ursus americana*). The specific topics addressed include hunting and recreational opportunity, conflict resolution, livestock depredation, and summarizes information on genetic sampling for population monitoring.

The strategies that follow are not Department policy or agenda, but provide an array of options based on published literature and professional experience that may be considered to achieve management objectives. Changes to Department guidelines and policies occur using public processes that may consider these strategies.

Hunting and Recreational Opportunity Strategies

Mountain Lion

1. Maintain multiple bag limit areas where the objective is a reduction of mountain lion abundance. This will allow hunters to continue to participate in mountain lion hunting in areas that will benefit other wildlife species to meet specific management objectives.

2. Maintain open hunting where female harvest does not indicate the need for reductions in resident mountain lion abundance (e.g., adult females do not comprise >35% of the harvest for four consecutive years) and management objectives do not include reducing the abundance of mountain lions in that unit or portion of that unit. Continue to protect spotted kittens and females accompanied by spotted kittens.

3. Evaluate an experimental harvest limit zone among units if adult female mountain lions comprise a high (e.g., >35%) proportion of the annual harvest and population reduction is not the management objective. Manage harvest through the establishment of a harvest limit on females under an experimental, adaptive management approach. Following inception of such a limit zone, harvest in the zone should be monitored closely during a 5-year period to assess total harvest and age and sex of mountain lions harvested. Mountain lion home ranges generally encompass multiple units and larger areas of consideration are needed to evaluate efficacy.

4. Continue to collect genetic material from harvested mountain lions to determine interrelatedness within broad vegetative communities. The degree of interrelatedness can be used to infer population changes over time within vegetative communities.

Bear

1. Continue with the current conservative management strategy of season and annual female harvest limits to manage Arizona's bear population, while protecting females with cubs.

2. Reduce harvest of females in units that exceed annual female harvest limits on a consistent basis (e.g., 3 out of 5 consecutive years) and median age of harvested females within the hunt area is <5 years by reducing the number of seasons or shortening seasons to less than the current 6-day structures. Use DNA techniques to estimate minimum population sizes in these units.

3. Use DNA studies in conjunction with age and sex data to better estimate minimum population numbers by vegetative communities. Adjust female harvest limits for hunt areas with the best available data, including DNA-supported minimum population estimates.

4. Continue to collect genetic material from harvested bears to determine interrelatedness within broad vegetative communities. The degree of interrelatedness can be used to infer population changes within vegetative communities over time.

Human-Wildlife Conflict Resolution Strategies

Mountain Lion

1. Continue to educate the public using Department biologists familiar with mountain lions and human-mountain lion conflicts in addition to administrators, public information personnel, and outside consultants.

2. Continue to provide specialized carnivore conflict resolution training for specific personnel focused in areas where projected growth will occur and places likely to result in continued human-mountain lion interactions.

3. Invest in a science-based educational program, such as Washington State's Project C.A.T. (Cougars and Teachers), using the Department's Focus Wild lesson plans to assist in educating the public and agency personnel.

4. Continue to use Department Policy I1.10 as the guiding policy during the Department's responses to calls concerning human-mountain lion conflicts.

5. Pursue regulations prohibiting feeding of wildlife into additional counties, cities, or portions of counties as Arizona's population increases and urban areas and high-use recreation areas interface with high mountain lion density habitats. Build partnerships with other agencies that are also responsible for enforcement of wildlife feeding regulations.

6. Incorporate geospatial analyses from the collection of GPS location data at sites of investigated conflicts for improved identification with consistent conflict areas. Maintain and update all related databases.

Bear

When dealing with human-black bear conflicts there are two fundamental considerations for strategy development:

- Preventing the development of conditioned problem bears.
- Managing problem bears once they are conditioned to the presence of humans.

1. Continue with the aggressive Bear Aware program that targets communities in and adjacent to bear habitat. Enact or enforce ordinances concerning feeding wildlife and work with local municipalities to discourage planting of vegetation that attracts bears.

2. Work with local municipalities and land management agencies within areas where nuisance bear problems exist to implement waste management policies encouraging the use of bear-resistant garbage containers and evening collection times to eliminate nighttime attractants.

3. Balance the goals of maintaining viable black bear populations, protecting human safety and property, and satisfying the needs of stakeholders in a cost-effective manner. Hunting and proactive education and awareness programs are keys to achieving that balance.

4. Continue to provide specialized carnivore conflict resolution training for specific personnel because Arizona's projected growth will occur in places likely to result in continued human-bear interactions.

5. Continue to use hunt structures, including spring and population management hunts, to address nuisance bear situations adjacent to municipalities.

6. Collaborate with land management agencies to treat vegetation adjacent to municipalities within bear habitat to discourage bear habitat use within wildland urban interfaces (WUIs). Treat vegetation to improve bear foraging habitat, while protecting necessary screening cover, in locations away from WUIs.

Wildlife Predation Strategies

Mountain Lion and Bear

1. Continue to use site-specific predation management plans as directed through the Commission's Predation Management Policy to address situations where other wildlife species have been recently translocated or where the other wildlife species is below population management objectives.

2. Evaluate the need to expand the geographic area of site-specific predator management plans on a regional basis where mountain lions are the identified predator of management need and adverse impacts on wildlife populations are documented. Develop and evaluate broader regional predation management plans where other wildlife species objectives have not been met and predation is a contributing factor.

3. Continue to use multiple bag limits to provide increased hunter opportunity within hunt areas where increased removal of mountain lions may benefit prey species that are below management objectives. Multiple bag limits may allow the targeted removal of specific animals through hunter harvest.

4. Continue to use Department or contract personnel trained in capture methods to remove mountain lions in areas identified in predator management plans.

5. Intensive harvest of female mountain lions in an area could theoretically reduce mountain lion predation on wildlife because male mountain lions may spend less time in areas with fewer breeding females. Implementation of this strategy should be experimental and adaptive to test efficacy of approach.

Livestock Depredation Strategies

Mountain Lion and Bear

1. Intensive harvest of female mountain lions in an area, even though they are responsible for comparatively fewer cattle depredations than are males, could theoretically reduce mountain lion depredations on cattle because male mountain lions may spend less time in areas with fewer breeding females. Implementation of this strategy should be experimental and adaptive to test efficacy of approach.

2. Collaborate with Wildlife Services, guides, ranchers and the land management agencies where depredations of livestock by mountain lions and black bears occur to increase additional hunting and guiding opportunity under the current depredation law A.R.S. § 17-302 and associated Commission Rule A.A.C. R12-4-305(H).

3. When appropriate, use current hunt structures (limit, population management hunts, and multiple bag limits) to increase the harvest of mountain lions and bears in areas of high livestock depredation caused by mountain lion and black bear.

4. Work with livestock producers and land management agencies to employ innovative livestock and husbandry practices that reduce the risk of depredation, such as the avoidance of calving operations within mountain lion habitat.

MOUNTAIN LION AND BEAR CONSERVATION STRATEGIES REPORT

BACKGROUND

The Arizona Game and Fish Commission annually sets goals and objectives for the Director. On May 1, 2008 the Commission approved the following goal:

Goal 5: During calendar year 2008, review, revise, and report on mountain lion and bear conservation strategy plans to include the following in one document: Hunting and recreational opportunities; human-predator conflict resolution strategies; urban predator conflict strategies; wildlife predation strategies; and livestock depredation strategies.

Under the powers and duties of the Commission as listed in Title 17 of the Arizona Revised Statutes (2007), Article 3, subsection 17-232, A. the Commission shall: Establish broad policies and long-range programs for the management, preservation, and harvest of wildlife. The use of the words long-range in direct association with management, preservation, and harvest support the development of strategies for conservation and sustainability of Arizona's wildlife. This report was developed with conservation as the key strategic objective and as strategy guidance from the Commission to the Department for managing mountain lions and black bears on a sustained yield basis.

The Commission approved a predation management policy in October 2000. In October 2004, the Department completed a detailed evaluation of predator management policies through a cross functional team that involved five subteams to review the biological foundations; social aspects; population biology; public health, safety, and nuisance; and information and education needs as it pertained to management of all predators, including black bears and mountain lions. A protocol was also developed in 2004 through an extensive public process to address human-mountain lion encounters. The protocol primarily guides agency response in the event of an encounter. While these efforts were thorough, the Department did not develop specific conservation strategies for mountain lions or black bears. Instead they focused on aspects of broad importance to the public and agency management actions, largely in response to human-predator conflicts.

INTRODUCTION

Large carnivores present major challenges to conservation and management. Large carnivores can cause human or livestock injury and mortality and can reduce their prey substantially in some situations. In the recent past, Arizona was inhabited by populations of five large carnivores: black bear, grizzly bear (*Ursus arctos*), wolf (*Canis lupis*), jaguar (*Panthera onca*), and mountain lion. Grizzly bears were extirpated about 1935 (Davis et al. 1982). Wolves were also extirpated, yet were reintroduced in March 1998 (Ballard et al. 2000). Jaguars (*Panthera onca*) have been confirmed within the state recently, but there have been few confirmed tracks or photos (Emil McCain, personal communication, 2008); their abundance is obviously low in Arizona. Only mountain lions and black bears remain in Arizona in large numbers.

The Department's mission to conserve, enhance, and restore Arizona's diverse wildlife resources includes the management of mountain lion and black bear. Current management largely relies on monitoring harvest trends and analyzing harvest composition to determine relative level of exploitation. Relatively crude estimates of abundance are available across the occupied range. The Department has investigated the use of track surveys to monitor mountain populations, which was found to be cost prohibitive and insensitive to all but large population size changes (Beier and Cunningham 1996). Genetic techniques promise to be the tool that will provide effective population monitoring tools, although they have as yet to be broadly implemented.

HUNTING AND RECREATIONAL OPPORTUNITY STRATEGIES

Figure 1. Mountain lions provide substantial recreational opportunity for hunters annually in Arizona.

MOUNTAIN LION

Hunting provides substantial recreational opportunity to thousands of Arizona hunters annually (Figure 1). In addition, hunting harvest is the primary mechanism for population-level management of mountain lions across western North America. But hunting can reduce the mean age of adult females and males in the population, alter population sex ratios, and reduce local abundance (Ross and Jalkotzy 1992, Anderson and Lindzey 2005, Stoner et al. 2006). Anderson and Lindzey (2005) suggest using sex and age ratios in the harvest to monitor lion populations as an adaptive management indicator for maintaining an appropriate harvest. Arizona is among the few states where mountain lion hunting is not influenced to a large degree by the sustained prevalence of snow throughout much mountain lion range.

One of the major difficulties with mountain lion management is that direct survey counts of mountain lions are not feasible, due to their secretive behavior, propensity for nocturnal movements, low abundance, and distribution in rugged terrain with abundant cover. Despite this difficulty, mountain lion hunting harvest levels of 10–30% of an estimated mountain lion population seem sustainable (Lindzey et al. 1992, Ross et al. 1996). Experimentally, harvests of 25–50% to reduce estimated mountain lion populations have been used to examine effects of exploitative harvest levels on demographics (Anderson and Lindzey 2005) or to study potential effects of mountain lion population reductions on prey demographics (McKinney et al. 2006*b*).

Harvest levels of about 20% are not likely to reduce mountain lion populations (Laundré et al. 2007), but sustained harvest of >40% of a mountain lion population for >4 years might have significant impacts on population dynamics and demographic composition (Stoner et al. 2006). In an unhunted population of mountain lions in the San Andres Mountains, New Mexico, the adult population of mountain lion consisted of a 1:1 male:female sex ratio, comprised 61% adults, 6% subadults, and 33% cubs, average number of live cubs/female/year varied between 2.0 and 1.3, cubs were born during every month of the year, gestation averaged 92 days, birth intervals averaged 17.4 months, females reached puberty at about 21 months and males about 24 months, females giving birth in a portion of the study area was 52 percent and an average of 76 percent were raising cubs each year (Logan and Sweanor 2001). Mountain lions less than three years of age are considered subadults, while those over three are considered adults (Cougar Management Guidelines Working Group [CMGWG] 2005).

As an alternative to direct survey, indices have been proposed as alternative methods to survey lion populations. Indexing sign surveys, such as track counts, scent stations, and capture-mark-recapture methods, have limited applicability for broad scale management programs that encompass diverse environmental conditions (Long et al. 2003, CMGWG 2005, Choate et al. 2006). Another indirect method, mark-recapture genetic data collection, has potential for cost-effective, statistically-valid population estimates if restricted to defined geographic management areas for initial sampling efforts, but then can be applied to similar habitats and acreages (DeSimone et al. 2008).

Current Management in Arizona

The Department's goals are to manage predators in a sustainable manner integrating conservation, use, and protection, and to develop the biological and social data necessary to manage predators in a biologically sound and publicly acceptable manner. Overall, mountain lion hunting is meeting the Department's management objective of maintaining an annual harvest of ≥250 animals/year and providing recreational opportunities for ≥6,000 hunters per year. Harvest and tag sales have met or exceeded these levels during recent years (Figure 2).

A mountain lion tag is required to harvest a mountain lion in Arizona, and tags are available in unlimited number over the counter each year. Thus, individuals can hunt mountain lions anywhere in the state during a nine month season from September–May. Hunters are restricted such that: 1) in general a hunter each year can purchase only one tag and harvest only one mountain lion, 2) hunters can harvest any mountain lion except spotted kittens or females accompanied by spotted kittens, and 3) the legal hunting season is closed June–July–August. Additional tags may be purchased for hunting within areas designated as multiple bag limit areas as subunits within selected units.

Between 1990–2007, 5,047 mountain lions were harvested in Arizona. Annual harvests ranged from 205–384 and varied among years ($\bar{x}$ = 280) (Figure 2). The number of mountain lion tags sold annually increased from about 3,000 in 1990 to nearly 11,000 by 2007 (Figure 2).

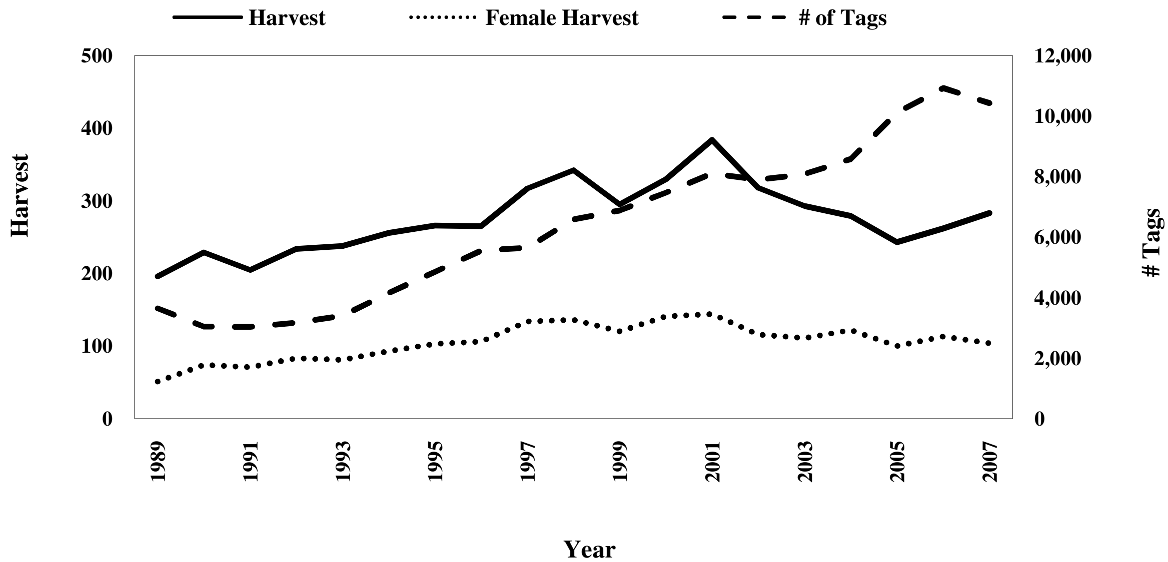

Figure 2. Mountain lion harvest, female mountain lion harvest, and number of tags sold annually in Arizona, 1989–2007.

Harvest among units is highly variable and ranged from two to 66 mountain lions among 36 units (Table 1).

Hunters using hounds during 1990–2007 accounted for a variable proportion of hunter harvest among units, ranging from 35.7–100% (Table 1). Statewide, hunters using hounds accounted for about 65% of the harvest. Hunters using hounds harvested 586 male and 547 female mountain lions statewide, although the sex ratio of mountain lions in the harvest varied among units (Table 1). Although males comprised a slightly higher proportion of the statewide harvest than did females, fifteen units had harvested M:F ratios <1:1 and 21 had harvested M:F ratios ≥1:1 (Table 1).

Sex and age data of annual mountain lion harvest are an indicator of harvest rate and population trend (Anderson and Lindzey 2005). Generally speaking with most polygynous species, management objectives target the harvest of the male segment. Hunting strategies strive to remove animals that are considered an annual harvestable surplus from a population on a landscape scale. Evaluation of age and sex structure of harvested mountain lions allows biologists to better understand the degree of exploitation on hunted mountain lion populations.

In Arizona, all successful hunters were required to submit a premolar tooth from their harvest for aging purposes (cementum annuli analysis) beginning in 2004. Beginning in 2007, hunters were required to physically present their harvested lion for age and sex verification. Field-aging techniques for mountain lions have questionable accuracy and precision (Ashman et al. 1983, Shaw 1990, Laundré et al. 2000, Anderson and Lindzey 2005), making it difficult to accurately confirm the age structure of harvest without additional lab analysis. Based on tooth cementum

Table 1. Mountain lion hunter harvest, depredation harvest, percent of hunter harvest taken by hound hunters, harvest of females and males, and ratio of males harvested per 100 females (M:F) in 36 game management units in Arizona, 2003–2007.

Unit	Hunter Harvest	Depredation Harvest	Percent of Harvest Using Hounds	Female Harvest	Male Harvest	Ratio of M:100 F in Harvest
1	17	1	82.4	4	13	325
2B	4	0	75.0	3	1	33
3BC	13	0	76.9	6	7	14
4AB	21	0	76.2	7	14	200
5AB	22	0	77.3	10	12	120
6	58	0	67.2	33	25	76
7	29	0	89.6	10	19	190
8	23	0	73.9	12	11	92
9	18	0	66.7	10	8	80
10	28	0	35.7	16	12	75
11M	3	0	100.0	1	2	200
12AB	41	0	92.7	17	24	141
13AB	16	0	75.0	7	9	129
15A-D	6	0	66.7	3	3	100
16	8	0	100.0	5	3	60
17AB	63	9	77.8	29	34	117
18AB	45	19	62.2	26	19	73
19AB	29	1	62.1	21	8	38
20A-C	66	1	77.3	28	38	136
21	25	0	72.0	15	10	67
22	60	0	73.3	27	32	119
23	65	0	58.5	30	35	117
24AB	64	3	64.1	23	41	178
27	45	22	48.9	23	22	96
28	13	61	76.9	7	6	86
29	26	1	61.5	13	13	100
30AB	43	0	83.7	19	24	126
31	29	49	55.2	18	11	61
32	39	32	51.3	18	21	117
33	48	0	56.3	16	32	200
34AB	61	0	55.7	37	24	65
35AB	15	0	46.7	5	8	160
36A-C	64	1	46.8	31	33	106
37AB	23	0	65.2	13	10	77
42	4	0	50.0	3	1	33
44A	2	0	50.0	1	1	100

analysis by sex of harvested mountain lions statewide during 2004–2006, subadults (≤2 years of age) comprised 53% of the usable samples submitted for analysis. Subadult females comprised 31% of samples, subadult males comprised 22% of samples, adult females comprised 21% of samples, and adultmales comprised 26% of samples. Average age of harvested mountain lions during this period did not change markedly (Table 2).

Arizona, along with most other states, limits harvest of females with kittens by regulation. The effectiveness of this approach to protecting female mountain lions with young is limited by the ability of hunters to identify females accompanied by young (Barnhurst and Lindzey 1989, CMGWG 2005). Females and males are difficult to distinguish, particularly for hunters not using hounds. During 2003–2007, Units 6, 10, 18A and B, 19A and B, and 21 had hunter harvest ratios of ≤76 male mountain lions per 100 females, with total hunter harvest of mountain lions ranging from 38–76 males per 100 females (Table 1). Although preliminary, sex ratios of adults harvested in these units had more females in the hunter harvest than males. Among subadults harvested statewide, the sex ratio tended to approach 1:1 during this time period. According to Anderson and Lindzey (2005), when adult females consistently comprise >35% of the overall harvest, resident mountain lion abundance may be reduced.

Although similar in some respects, Arizona's approach to harvest management of mountain lions differs in other ways from methods used by some western states or proposed by some biologists. In Utah, mountain lion harvest is managed within large areas either conservatively as a trophy species or liberally where they are believed to be a limiting factor affecting population growth of native ungulates (Stoner et al. 2006). In British Columbia, a draft harvest management plan was developed that includes the use of refuges (unhunted areas) to limit harvest of mountain lion populations (Austin 2005). Limit zones (areas with harvest limits closing hunts when reached) were established in Washington (Beausoleil et al. 2005) and Oregon, the latter of which also banned use of hounds through a voter initiative (Whittaker 2005). Limits for harvest of female mountain lions are used in Idaho (Nadeau 2005) and for total and female mountain lion take in Montana (DeSimone et al. 2005). In Wyoming, the Game and Fish Department is fiscally liable for confirmed livestock losses; they follow an open hunting policy that protects kittens and females with kittens at side and requires mandatory check-out of successful hunters (Moody et al. 2005).

Hunting of mountain lions is prohibited in California, but limited hunting may be developed in the future; the number of depredation permits issued and mountain lions taken increased dramatically between 1972 and 2004, when legal hunting of mountain lions was terminated (Updike 2005). Nevada employs an open hunting system with mandatory check-out of successful hunters. Depredation harvest averages about 12% of hunter harvest, and any hunter may obtain two mountain lion tags annually (Woolstenhulme 2005). Colorado does not use female subquotas, but harvest limits can be established for one or more of 19 Data Analysis Units (Apker 2005). Finally, New Mexico is divided into mountain lion management zones (MLMZ), each of which may comprise one or more of the state's game management units. Population objectives for each MLMZ depend on several factors, but protection of bighorn sheep (*Ovis canadensis*) populations and livestock depredation strongly influences mountain lion management prescriptions (Winslow 2005).

Table 2. Average age for harvested male and female mountain lions in Arizona, 2004–2007.

	2004	2005	2006	2007
Number of males	37	66	78	101
Average age of males	3.2	3.2	2.8	3.7
Number of females	56	54	78	76
Average age of females	2.7	2.7	2.6	3.3

British Columbia's draft plan allowing pursuit-only seasons that would allow hound hunters to chase but not kill mountain lions (Austin 2005). Washington developed a three-year pilot program authorizing pursuit-only hunting (Beausoleil et al. 2005). Hunting with hounds was banned in Oregon through a voter initiative, resulting in an initial drop in total mountain lion harvest, but increased tag sales and expansion of season dates and legal hunting areas led to higher harvest levels than prior to the ban on using hounds (Whittaker 2005). Idaho expanded hunting seasons after 2002, allowed hound hunting in most management units, and increased non-resident hound hunting, but statewide harvest declined between 1999 and 2004 (Nadeau 2005). Hunting with hounds is allowed in Montana during the winter season, and all license holders may pursue and chase (pursuit only) mountain lions, even within districts where limits have been reached. Total mountain lion harvest peaked in 1998 and declined through 2004 (DeSimone et al. 2005). Pursuit-only hunting is not authorized in Wyoming (Moody et al. 2005) and there is no pursuit-only season in Nevada (Woolstenhulme 2005). There are no definitive data regarding impacts of pursuit-only seasons (CMGWG 2005), but multiple chases may have detrimental physiological effects on mountain lions (Harlow et al. 1992).

Review of Hunting Structures: Open Hunting

Open hunting, currently used to manage mountain lions in Arizona, allows harvest of unlimited numbers of mountain lions of either sex in areas delimited only by hunter choice during a legal hunting season (Laundré and Clark 2003, CMGWG 2005). Open hunting is a method that historically has been used throughout the West. Other systems based on limits, metapopulation structure, and zone management concepts are of more recent vintage, and have been proposed or are being used in some areas of western North America. Results of several studies suggest that intense harvest under an open hunting strategy correlate with reduced short-term survival rates or local reductions in abundance of mountain lions (Lindzey et al. 1992, Ross and Jalkotzy 1992, Anderson and Lindzey 2005, Lambert et al. 2006, Stoner et al. 2006, McKinney et al. in press). However, long-term reductions in local abundance and survival are poorly understood because they may be offset by immigrations from surrounding areas (Cunningham et al. 2001). Logan and Sweanor (2001) noted that a positive correlation between number of tags sold and harvest totals may indicate that a population may be harvested at a rate that would reduce resident mountain lion abundance over time. In Arizona, although there is a positive linear correlation between tags sold and mountain lion harvest, the relationship only explains about 12% of the variation observed between 1971 and 2007 ($Y = 199.8 + 0.001X$; $P = 0.04$; $r^2 = 0.124$). Tag sales and harvest does not suggest a strong relationship either (Figure 2).

Limited Entry-Limit Management Systems

Limited entry systems control the number of hunters allowed to hunt in a given area by limiting the number of licenses sold (CMGWG 2005). Limit systems (Ross et al. 1996, CMGWG 2005) set a limit on legal harvest of numbers of mountain lions during a season or in a particular area. Limits may be set on harvest of total mountain lions, numbers of females, or number of males. Hunting seasons close when the specified numbers of qualifying animals are killed or continued harvest of males may be permitted after a female limit is reached. Depending on management objectives, limit systems may be used to regulate distribution of hunting pressure, increase or reduce harvest levels, or tailor sex composition of the harvest (Ross et al. 1996, CMGWG 2005).

Using a sex-specific harvest in the limit system may allow for a greater than desired harvest on the other sex. On the other hand, sex composition of the harvest may be skewed with a total mountain lion harvest limit or limited entry hunting (Laundré and Clark 2003). Moreover, sex may be difficult for hunters to distinguish prior to harvesting a mountain lion, which may contribute to inadvertent violations. Colorado requires hunters to participate in a mountain lion hunting field identification course before hunting. This is the first year of this program and no data exists to demonstrate its effectiveness. Decisions leading to use of limits may be based on one or several goals. Limits may be set as >20% of total harvest of an estimated population size or to reduce female harvest.

Despite the apparent logic of the limit system, each limit is based on a rather crude estimate of mountain lion abundance at broad landscape scales. To improve mountain lion population abundance estimates to establish limits, intensive long-term mark-recapture research to estimate population size could be conducted over a small area, and those estimates could be extrapolated over a broader area. Use of genetic sampling methods could reduce the intensity of this effort. Qualitative estimates of abundance within specific zones might need to be derived from habitat similarity, harvest and incident records, and consultations with local wildlife managers, houndsmen, trappers, and others presumed familiar with an area (Ross and Jalkotzy 1992, Ross et al. 1996). The precision of such a method however, is impossible to estimate and the accuracy would likely be poor. A limit system approach could erroneously result in increased harvest of mountain lions (Ross et al. 1996). Data supporting limits will be expensive and difficult to obtain.

A number of Arizona's units have an apparent high proportion of female mountain lions in the annual harvest. However, small harvest sample sizes may cloud this conclusion. Limiting harvest of female mountain lions on a unit by unit basis would only serve to reduce female harvest if the limit was less than the long term average harvest of females in all or some of these units.

Zone Management System

Zone management approaches acknowledge the need for a landscape-scale method for mountain lion management. Zone management recognizes the existence of source (areas where recruitment is higher than mortality and provides a source for dispersal animals) and sink (areas where mortality exceeds recruitment and dispersal animals tend to move into) metapopulation structures and employs adaptive management objectives. Under zone management, Arizona could be partitioned into relatively large zones with different management objectives; management in each zone could be approached as an experiment, with its own objectives, hypotheses, and prescriptions. Three kinds of management zones have been suggested. These zones are 1) control zones, where the objective is reduction of mountain lion abundance, 2) hunting zones, where the objective is sustaining populations to provide sport hunting opportunities, and 3) source zones, where no hunting is allowed and the objective is to sustain reliable source populations.

For the zone management system to be effective, agency biologists should estimate limits to annual mountain lion harvest within control and sport-hunting zones, use existing data on abundance and distribution of mountain lions within the state, map out potential subpopulations that are sources and sinks, and gauge effects of harvest in control and sport-hunting zones by determining tendencies of rates of population change (Logan and Sweanor 2001). These procedures require data based on intensive and extensive research on marked animals, which of necessity is limited to localized study areas.

Alternatively, genetic sampling from a limited area of a zone could be used to estimate population abundance. DNA collected from multiple approaches can be used as mark-recapture data to estimate abundance. Collecting sufficient samples would necessitate use of a combination of methods, such as 1) collecting samples from hunter-killed animals, 2) retrieving hair snares located within the zone, and 3) obtaining biopsy samples from mountain lions using hounds to tree and specialized darts to obtain samples.

The role mountain lion source areas play on the larger landscape is poorly understood. Source areas function as refuge zones, provide dispersers for numeric and genetic augmentation of control and hunting zones, reduce influence of local harvest that could reduce populations in hunting zones, and serve as reference areas for research and monitoring studies (Logan and Sweanor 2001, CMGWG 2005). The degree of mountain lion movement across Arizona's borders is unknown. For an area to serve as a source, it theoretically must provide a resident adult population of 30–50 animals with linkages to other mountain lion habitats (Beier 1993).

Under a zone management system, an adaptive management approach could combine multiple contiguous units into a single zone. For example, five units combined into a single hunt area (i.e., a zone; Figure 3) and managed with a limit on harvest of female mountain lions (Table 3).

Within zone management, a harvest limit of 10 females per year within a female harvest limit zone could be established within Units 6A and 6B, 10, 18A and 18B, 19A and 19B, and 21. During 2003–2007, 22 females per year were harvested within this group of units. A female harvest limit of 10 within these combined units could reduce female harvest by about 54%. This limit would also place the responsibility of identifying sex of mountain lions on hunters prior to harvest and may shift proportion of harvest toward the male segment. Within a female harvest limit zone, the continued harvest of males could be permitted once the female limit is reached, which would provide extended hunting opportunities, although inadvertent violations might occur at a relatively high rate.

Table 3. Arizona units, mean harvest and sex ratio during 2003–2007, and an example of a possible female harvest limit that may be considered for establishing a zone where a female harvest limit may address the high proportion that female mountain lions comprise in the annual harvest.

	Sport Harvest per Year			Male:100 Female Ratio in Harvest	Female Limit	Average Annual Depredation Harvest
Unit	Average	Female	Male			
6AB	11.6	6.6	5.0	76	3	0
10	5.6	3.2	2.4	75	1	0
18AB	9.0	5.2	3.8	73	3	3.8
19AB	5.8	4.2	1.6	38	2	0.2
21	5.0	3.0	2.0	67	1	0

Currently, no evidence suggests that mountain lion abundance in the example zone is being reduced, other than the sex ratio in the harvest. Data on age and sex could assist in this assessment, but should be considered as trend over time rather than a single year snapshot. Population estimates generated from genetic sampling could be used to determine if a more restrictive harvest management approach is needed. There will be added costs with this level of monitoring.

The zone limit example represents primarily a snow belt extending from northwest to southeast. All areas within this zone may not be hunted equally due to differences in mountain lion densities, road access, and snow conditions (Ross et al. 1996, Robinson et al. 2008). Most mountain lions in Arizona are killed by hunters during October–April (Zornes et al. 2006), a period of seasonally higher snowfall. Moreover, the zone limit represents a region of estimated medium to high mountain lion densities and comparatively higher levels of sport harvest (Phelps 1989).

Hunters using hounds (selective hunters) take about 65% of the mountain lions harvested in Arizona, and their harvest averages about 37% females. In contrast, hunters that don't use hounds (non-selective hunters) harvested about 35% of the total harvest of mountain lions, and their harvest on average is comprised of about 62% females. Disproportionate harvest of females by non-selective hunters may be because they tend to kill mountain lions at a greater distance, likely are less able to distinguish sex, and likely attempt to kill the first mountain lion they see. Hound hunters harvest about 21% subadults, whereas non-selective hunters harvest about 43% subadults (Zornes et al. 2006).

Because female mountain lions tend to be philopatric (Logan and Sweanor 2001), reduced harvest of adult females may be a viable management strategy for sustaining mountain lion populations (Lindzey et al. 1992, Ross et al. 1996, Lambert et al. 2006, Stoner et al. 2006). Determining age and sex of harvested mountain lions, emigration, and immigration may be necessary for identifying effects of harvest (Anderson and Lindzey 2005, Robinson et al. 2008). At present, harvest sex ratios (Table 1) do not indicate a need to consider establishing source

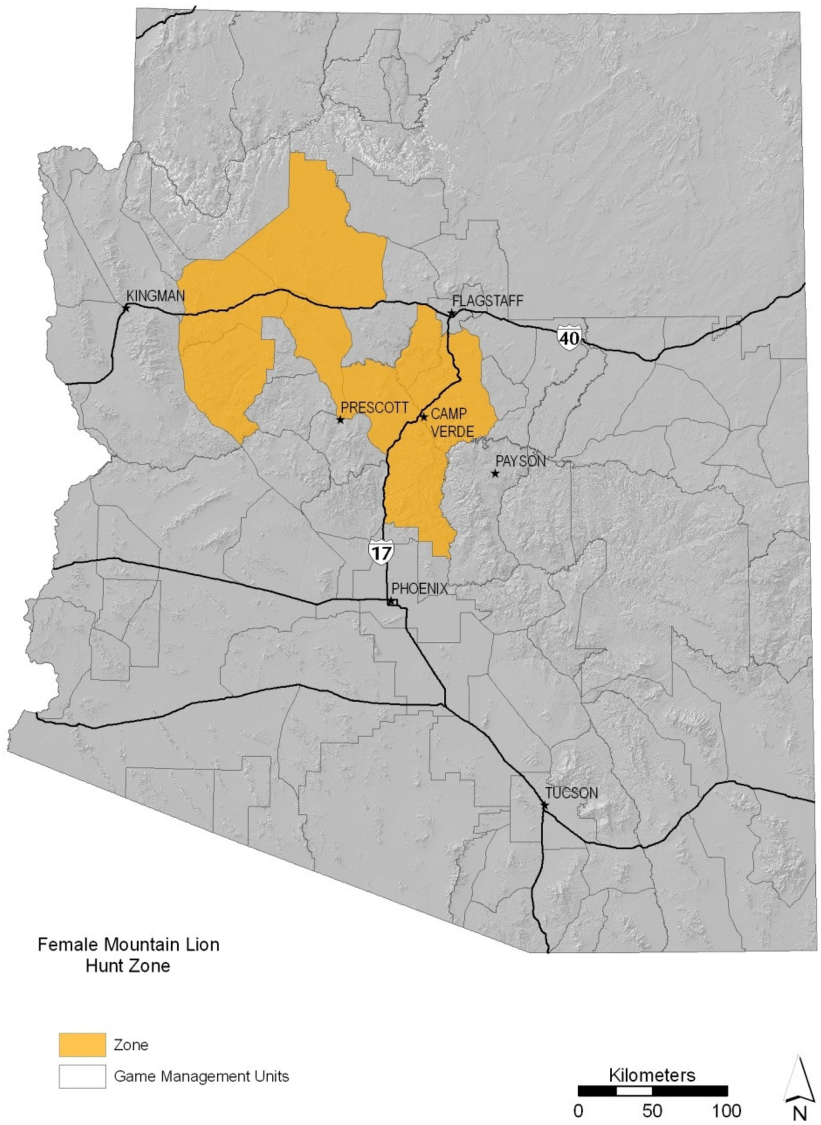

Figure 3. Example of a zone, based on historical harvest data, that could be established to manage female mountain lion harvests using a limit system.

zones (Logan and Sweanor 2001) encompassing units in Arizona that are located outside the zone limit area.

Role of Sources and Sinks in Zone Management

Metapopulations involve local subpopulations occupying discrete, suitable patches of habitats that interact via dispersal of individuals moving through a matrix of suitable and unsuitable habitats, buffer against extirpation by gene flow among subpopulations, or contribute to postextirpation recolonization (Baguette 2004). Movement among suitable habitat patches is not routine under true metapopulation dynamics.

Metapopulation theory has become a common framework in conservation biology, yet its use remains somewhat contentious and uncertain (Baguette 2004, Hanski 2004, McCullough 1996). Metapopulation analysis may be the current approach to many modern wildlife conservation and management issues (McCullough 1996), but little analysis has been conducted for mountain lions. Although the metapopulation approach is often suggested for management of large mammals, little empirical support for metapopulation dynamics has been found (Elmhagen and Angerbjörn 2001). A metapopulation approach might be interesting for large mammals when there are discrete breeding subpopulations that have different growth rates and demographic fates, rather than subpopulation turnover (Elmhagen and Angerbjörn 2001).

The two keys to the present concept of metapopulations of mountain lions are: 1) spatially discrete distributions and 2) a non-trivial probability of extinction in ≥1 patches of localized habitats (i.e., subpopulations). Isolation of populations through fragmentation by human-related activities is the major conservation concern (McCullough 1996). Existence of metapopulations of mountain lions has been based on estimates of abundance on scattered mountain ranges and speculated occurrence of sinks and sources (Laundré and Clark 2003), but estimates of relative abundance and population size are influenced by the spatial extent of study areas (Smallwood 1997). Other research identified metapopulations based on evidence of dispersers between mountain ranges separated by unsuitable habitat and considerations of postulated gene flow between these ranges (Sweanor et al. 2000). Mountain lion research lacks well-supported comparisons of abundance, population growth rates, or demographic fates of animals between subpopulations within estimated metapopulation structures. We therefore conclude that existence of and relevance of metapopulations and source-sink structures to mountain lion management has been based on weak inference and limited scientific data.

The relevance of source-sink hypotheses and metapopulation dynamics remains theoretical when applied to mountain lion populations. Sources and sinks were defined originally in terms of birth, death, emigration, and immigration (Pulliam 1988). Although the concept of source-sink dynamics has become widely appealing in wildlife ecology and management, application of the theory and the ability to estimate source-sink dynamics in natural populations has proved to be very difficult (Novaro et al. 2005, Runge et al. 2006). Studies concentrating solely on adult survival produce erroneous conclusions regarding sinks when they ignore data on natality, emigration, and immigration (Runge et al. 2006). These data are presently unavailable for most mountain lion populations.

Genetic analyses failed to demonstrate population subdivisions within Arizona (Sinclair et al. 2001, Anderson et al. 2004, McRae et al. 2005)., although gene flow between and within northern regions (Utah, Colorado) and southern regions (Arizona, New Mexico) appeared to be strongly limited by distance, particularly in the presence of habitat barriers such as open deserts and grasslands (McRae et al. 2005). Thus, existence of mountain lion metapopulations in Arizona is unclear and speculative.

Hunting may produce attractive sinks if dispersing individuals select habitats with abundant resources (cover and prey) and high human-caused mortality (Delibes et al. 2001). Previous research in Arizona (Cunningham et al. 2001, McKinney et al. in press) documented localized areas with high human-caused mountain lion mortality, but it is uncertain whether these areas represented sinks. If hunting is intense and widespread, heavy harvest pressures in areas of abundant cover and food resources might produce attractive sinks for dispersing mountain lions, thus maintaining or replenishing populations in sinks (Delibes et al. 2001, Novaro et al. 2005).

Identification of metapopulation structure and the existence of sources and sinks present substantial challenges to mountain lion managers. These theoretical constructs require considerable data to support their use. These data include estimates of animal density throughout metapopulation habitat patches, documented existence of sources and sinks with differing levels of abundance, estimates of population growth rates among areas within a metapopulation structure (Logan and Sweanor 2001, CMGWG 2005), and population demographics estimates. Using source-sink theory to manage mountain lion populations in Arizona would require a significant investment to conduct the extensive research needed to manage lions based on population-metapopulation dynamics.

Multiple Bag Limit Structures

Multiple bag limit hunt structures, used in Arizona since 1999, were established use hunters to harvest 50–75% of the estimated mountain lions living within an area, thereby reducing predation on a prey population. Multiple bag limits have not affected hunter harvest in a manner that approached the estimated harvest necessary to influence predation (Table 4). Harvest of mountain lions has differed little among management areas following the 1999 implementation of multiple bag limit structures and harvest did not differ statistically following implementation. The reason for this apparent lack of hunter response or change in hunter harvest within multiple bag limits is unknown, but factors such as relative access to hunting areas, absence or presence of snow conditions, methods of hunting, and perceived relative abundance of mountain lions affect hunter choices of hunting areas.

Predominant vegetation types and relative abundance of mountain lions vary widely among units where multiple bag limits apply. Multiple bag limits in Units 6AS, 13BS, and 27 are located in mixed pinyon (*Pinus* spp.)-juniper (*Juniperus* spp.) and ponderosa pine (*Pinus ponderosa*) forests which favor hunters under snow conditions. Hunters track mountain lions under these conditions by driving roads and releasing hounds when sign is encountered. Lack of hunter response to multiple bag limits in Units 6AS and 13BS may be due to perceived low-moderate abundance of mountain lions in these areas, remoteness, and poor road access. In contrast, lack of hunter response in Unit 27, where mountain lions are more abundant, might reflect limited duration of snow conditions and ruggedness of terrain. Hunters concentrate in areas with abundant, accessible roads during periods of snowfall but dwindle dramatically when the snow is gone. Thus, use of forested areas by hunters during good snow conditions relies on ready access and comparatively high abundance of mountain lions, while limitations of snowfall duration, ruggedness of terrain, remoteness, and poor road access likely limit or reduce hunter response to multiple bag limits.

In comparison, multiple bag limits in desert scrub habitats (i.e., Units 15A–D, 16A and B, 18A and B, 22, 40A, 42) often tend to have lower abundance of mountain lions, more difficult dry-ground hunting conditions, and relatively poor access by motor vehicles. Few hunters (whether using hounds or opportunistic hunting methods) like to walk and climb very far in difficult terrain, so few lions are hunted there. Comparatively few sport hunters own horses or mules or have the skills to effectively use these animals comfortably and safely in remote, rugged terrain. Most must hunt on foot or rely on guides for riding stock. Moreover, dry-ground hunters and the hounds they use successfully have different skill sets when compared to snow hunters. Most hounds with moderate trailing ability can follow mountain lions in snow, but few excel in trailing mountain lions over dry, rocky ground. In desert scrub habitats, relative lack of trees, steep slopes, and patches of cacti create problems for hunters and their hounds. Mountain lions are generally brought to bay on the ground or in bluffs due to the relative lack of trees, often leading to injury of dogs. Hunters are largely motivated by actual or perceived mountain lion abundance, relative ease of access, and success rate. As a result, whether or not a resource agency encourages hunting on specific areas is of little relevance to hunters. Sport harvests of mountain lions during recent decades have concentrated in central Arizona from northwest to southeast (Figure 4) in habitats characterized by abundance of tall shrubs and trees, as well as estimated higher abundance of mountain lions.

Multiple bag limits have not increased harvest of mountain lions, yet allow for hunters to participate in efforts to reduce predation in specific areas to meet specific management objectives. The Department has the ability to contract with mountain lion hunters in specific areas to reduce mountain lions under site specific predator management plans even without multiple bag limits. A zone management system incorporating the concept of control areas (objective is reducing predation or reducing abundance of mountain lions) may prove useful in achieving management objectives. Additional research may identify variables that consistently enhance use of multiple bag limits or control areas by hunters, provide better insights into how various designations may be used, and enhance management prescriptions.

Effectiveness and practical utility of limited entry, limit, and zone management strategies remains largely speculative because studies have been relatively short-term (≤11 years), replications are lacking, regions vary widely in habitat and available prey, and understanding is poor regarding variability in community structure. Moreover, little is known about either immediate or long-term effects of sustained harvest on mountain lion populations. Few studies have addressed questions of 1) how does harvest affect the demographic structure of a population, 2) the long-term implications for persistence and recovery of exploited populations within the metapopulation context, and 3) how habitat configuration and connectivity affect recruitment patterns (Stoner et al. 2006).

Table 4. Units with mountain lion multiple bag limits, multiple bag limit (MBL), and the number of animals taken during the season year in Arizona, 1999–2008. Columns with missing data (--) had no multiple bag limit for that unit during that year.

		Season Year (July 1 through June 30)								
Unit	MBL	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008
6A South	15	--	--	--	--	--	--	4	5	3
13A & 13B	15	3	6	10	3	4	--	--	--	--
13A South	5	--	--	--	--	--	1	--	--	--
13B South	10	--	--	--	--	--	0	2	0	3
15B West, 15C, & 15D	10	--	--	--	--	--	3	1	1	0
16A South & 18B South	17	--	0	5	4	3	--	--	--	1 (MBL Obj. 15)
21 West	8	--	--	--	--	0	3	6	0	--
22 South	12	5	6	1	2	1	1	1	5	0
27 – Bear Canyon	5	--	--	--	--	--	--	1	0	1
27 – Pipestem	10	--	--	--	--	--	--	3	0	0
28 South	10	--	--	--	--	0	0	0	--	--
37B North	4	--	--	--	--	0	0	0	--	--
40A	4	--	--	--	--	--	--	0	0	0
42 South	2	--	--	--	--	--	--	--	0	0

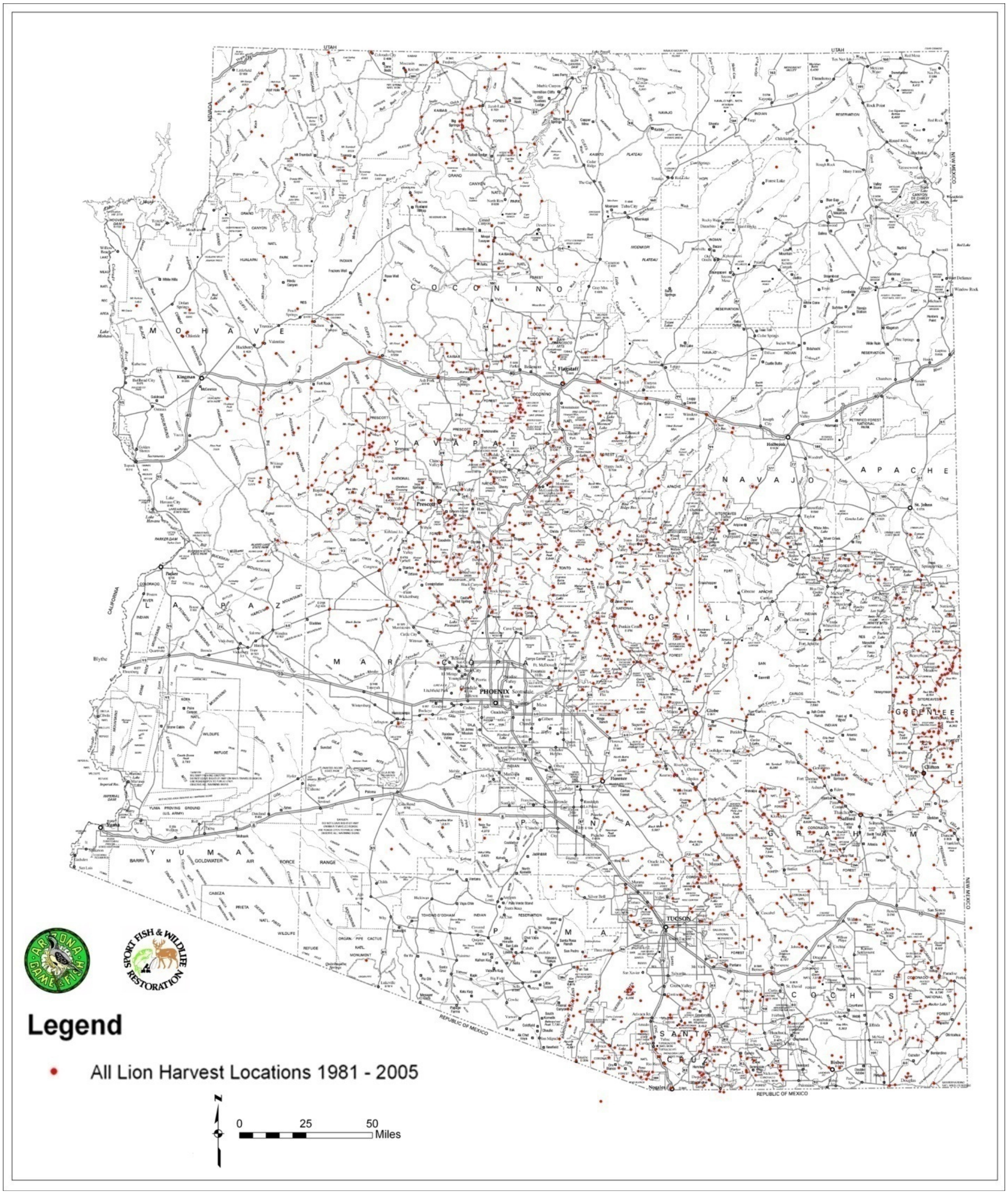

Figure 4. Distribution of reported mountain lion hunter harvest locations (red points) in Arizona, 1982–2005.

Summary

1. During 2004–2006 (when physical harvest checks were first initiated), subadults comprised on average 53% of samples, subadult females comprised 31% of samples, subadult males comprised 22% of samples, adult females comprised 21% of samples, and adult males comprised 26% of samples. This suggests a moderate statewide harvest rate and stable statewide population levels (Anderson and Lindzey 2005). Anderson and Lindzey (2005) recommend the use of long-term trend data to determine if harvest is reducing resident mountain abundance, which generally results when harvest composition exceeds 35% adult females. The open season strategy used by Arizona has no demonstrated influence on mountain lion abundance, but with increasing habitat fragmentation, limited entry or limit management strategies may be effective in specific areas to reduce female harvest if they ultimately comprise >35% of the harvest in the future.

2. There is little correlation between the number of tags sold and total annual hunter harvest of mountain lions in Arizona. No studies of limited entry, limit, or zone management have been conducted in arid or semi-arid regions comparable to mountain lion habitats in Arizona.

3. Direct survey counts of mountain lions are not possible, due to their secretive behavior, propensity for nocturnal movements, low abundance, and distribution in rugged terrain with abundant cover. These characteristics influence applicability of all techniques that monitor mountain lions.

4. Developing population density estimates for mountain lions on a unit by unit basis used as evidence for supporting limits will be expensive and difficult, although the use of genetic sampling methods show promise in reducing these costs.

5. An experimental limit restricting harvest of female mountain lions on a zone basis in Units 6A, 6B, 10, 18A, 18B, 19A, 19B, and 21 may be useful in reducing harvest of adult females and shifting harvest to the male segment of the mountain lion population in this area.

6. The relevance of metapopulations and source-sink structures to mountain lion management has been based on weak inference and deficiencies of good scientific data.

7. Genetic sampling from a limited, representative area of a biome or zone could be used to estimate population abundance in similar habitat types, although collecting the necessary data will require the assistance of hunters.

Management Strategies

1. Maintain multiple bag limit areas where the objective is a reduction of mountain lion abundance. This will allow hunters to continue to participate in mountain lion hunting in areas that will benefit other wildlife species to meet specific management objectives.

2. Maintain open hunting where female harvest does not indicate the need for reductions in resident mountain lion abundance (e.g., adult females do not comprise >35% of the harvest for four consecutive years) and management objectives do not include reducing the abundance of mountain lions in that unit or portion of that unit. Continue to protect spotted kittens and females accompanied by spotted kittens.

3. Evaluate an experimental harvest limit zone among units if adult female mountain lions comprise a high (e.g., >35%) proportion of the annual harvest and population reduction is not the management objective. Manage harvest through the establishment of a harvest limit on females under an experimental, adaptive management approach. Following inception of such a limit zone, harvest in the zone should be monitored closely during a 5-year period to assess total harvest and age and sex of mountain lions harvested. Mountain lion home ranges generally encompass multiple units and larger areas of consideration are needed to evaluate efficacy.

4. Continue to collect genetic material from harvested mountain lions to determine interrelatedness within broad vegetative communities. The degree of interrelatedness can be used to infer population changes over time within vegetative communities.

Figure 5. Many different habitat types and rough topography in Arizona make bear hunting challenging and productive for hunters.

BLACK BEAR

Black bears occupy a variety of differing habitats in Arizona, including subalpine and montane conifer forests, riparian forests, evergreen woodlands, chaparral, and oak savannah habitats. In recent years, bears have provided hunting opportunity for almost 5,000 hunters (Figure 5).

Black bears are polygynous, long-lived omnivores. Hibernation during winter for a period up to seven months may be an evolutionary strategy to increase survival (Jonkel and Cowan 1971). They are capable of rapidly altering their feeding behavior to adjust to environmental change (Ayers et al. 1986, Stirling and Derocher 1990). Subadult males exhibit lower survival rates than subadult females (Beringer et al. 1998; Lee and Vaughan 2003, 2005) or adult males (Bunnell and Tait 1985, Elowe and Dodge 1989, Schwartz and Franzmann 1992, Beringer et al.1998). This has been attributed to risks associated with dispersal (Schwartz and Franzmann 1992, Beringer et al. 1998, Lee and Vaughan 2005).

The age at which female bears have young and the annual proportion of females that reproduce successfully varies considerably with food supply or nutritional condition of females (Rogers 1987, Eiler et al. 1989, Kolenosky 1990, McLaughlin et al. 1994). In habitats with good to excellent food resources, female black bears may breed as early as three years of age and successfully raise litters at four years of age (McLaughlin et al. 1994). In poor habitats or during extended periods of drought, bears may not reproduce until as late as 6–7 years of age (Jonkel and Cowan 1971). The percentage of adult females with cubs averaged 53% per year for a bear population in central Arizona (LeCount 1984). Cubs, typically born in February while in the den, stay with the female throughout the first summer, and generally den with the female during the winter following their birth. Cubs disperse prior to the breeding season (May–June) of their second summer. Survival rates of cubs between 0.5 and 1.5 years of age have been estimated as high as 95% in the spruce forest (Jonkel and Cowan 1971). In Arizona, cubs between 2–3 years of age experience 79% survival (LeCount 1977).

Reproductive failure following years of food shortage is common in black bears (Jonkel and Cowan 1971, Miller 1994, Costello et al. 2003, Dobey et al. 2005). Female black bears use delayed implantation as a reproductive strategy. Upon mating, the fertilized ovum will divide a few times then float freely in the uterus for about six months without developing. Around denning time, the embryo will implant in the uterine wall. After about eight weeks, the cub will be born while the female is still in hibernation. Delayed implantation serves an important survival process for the female. If she fails to gain enough fat to carry her through the winter, the embryo will not implant and is then reabsorbed by her body (Middleton 1996).

Kemp (1972, 1976) erroneously concluded that bear populations are self-regulating, in part because adult male bears often kill young bears (Jonkel and Cowan 1971, LeCount 1982) and numerical population increases have occurred following removal of adult males. Subsequent reanalysis and study concluded that black bear populations do not self regulate or that bears dispersing beyond the periphery of their current range fare poorly (Garshelis 1994, Sargeant and Ruff 2001). Within hunted populations, sustainable hunter harvest and population abundance are sensitive to survival of adult females (Taylor et al. 1987, Horino and Miura 2000, Boyce et al. 2001). Management prescriptions should therefore be directed at protecting adult females in a black bear population. Primarily, adult females with cubs of the year are at the greatest risk of survival due to defense of young from male bears (Garshelis 1994, McLellan 1994, Swenson et al. 2001).

Current Management in Arizona

The Department's goal is to manage black bear population numbers and distribution as an important part of Arizona's fauna, while providing sustainable hunting and other related recreational opportunities. The Game Subprogram operational plan objectives are to maintain an average annual harvest of no more than 125 female bears (including hunter, depredation, and other take), with a total hunter harvest of 250 or more bears (all bears) (Figure 6).

The operational plan also identifies objectives to provide recreational opportunity to at least 4,000 hunters annually, maintain existing occupied habitat with emphasis on retention of medium and high quality habitats, and manage human-wildlife conflicts according to Department Policy DOM I1.10.

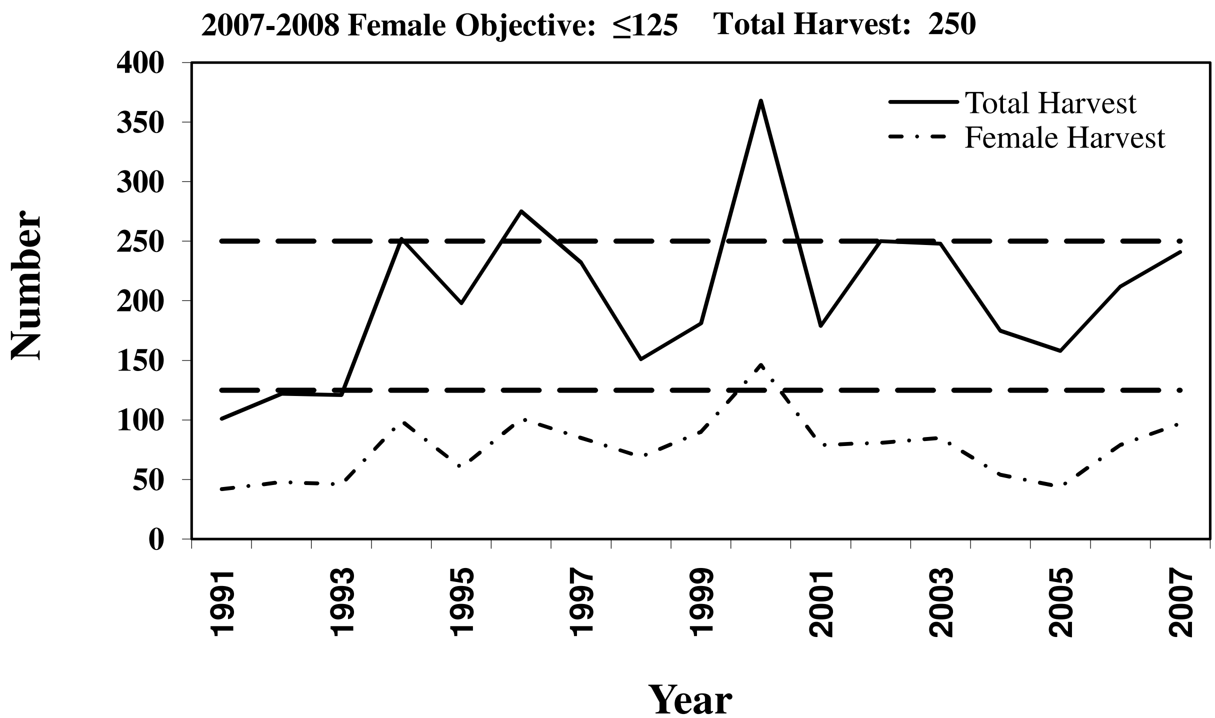

Figure 6. Black bear total and female harvest in Arizona, 1990–2007.

The Department maintains harvest data records that include age, sex, and kill location to monitor population trend information. Between 1990 and 2007, 3,674 black bears were harvested in Arizona (includes sport, depredation, and other kills) (Table 5).

On average, hunters using hounds accounted for 21% of the harvest. Among all units, hunters harvested 2,015 male and 1,367 female black bears between 1990–2007. The sex ratio of harvests (number of males:100 females) varied widely as well, but males comprised a higher proportion of the statewide harvest than did females. Eight units had harvested M:F ratios <1:1 and 26 units had harvested M:F ratios ≥1:1 (Table 5). The proportion of bears taken by hunters with hounds varies by unit and hunt structure (Table 5).

The number of bear tags sold annually has increased from about 2,800 in 1991 to nearly 5,000 in 2007. Harvest among units is highly variable and ranged from 1 to 58 bears in 36 units (Table 6). Annual harvest ranged from 101–368 and varied among years ($\bar{x}$ = 204).

Since 1981, all successful Arizona bear hunters have been required to report their bear kill and submit a premolar from the bear for age determination. Beginning in 2007, hunters were required to physically present their harvested bear for age and sex verification. Based on tooth cementum analysis by age and sex class of harvested black bears statewide during 2005–2007, subadults comprised 51.3% of the samples. Subadult females comprised 15.0% of samples,

Table 5. Total black bear hunter harvest, total depredation harvest, percent of sport harvest taken by hound hunters, total harvest of females and males, and ratio of males harvested per 100 females (M:100 F) in 33 game management units in Arizona, 2003–2007 (AZGFD 2008).

Unit	Total Hunter Harvest	Total Depredation Harvest	Total Other Kills	Percent Hunter Harvest Using Hounds	Total Hunter Male Harvest	Total Hunter Female Harvest	Ratio of M: 100F	Number of Other Kills that were Nuisance Bears
1	66	1	6	62.1	39	27	144	5
3B	40	0	6	70.0	25	15	167	6
3C	16	0	11	6.3	10	6	167	8
4A	27	0	4	48.1	19	8	238	4
4B	16	0	0	25.0	10	6	167	
5A	41	0	2	51.2	27	13	208	1
5B	14	0	1	64.3	10	4	250	
6A	41	0	1	24.4	31	10	310	
6B	31	0	1	6.5	19	12	158	
7	5	0	0	0.0	3	2	150	
8	28	0	0	21.4	20	8	250	
11M	1	0	1	0.0	0	1	0	
17A	2	0	0	50.0	1	1	100	
18A	0	0	1					
19A	14	0	0	7.1	8	6	133	
20B	1	0	2	100.0	1	0		1
21	22	0	0	0.0	16	6	267	
22	69	0	5	29.3	44	25	176	2
23	144	0	2	100.0	85	59	144	1
24A	32	0	10	0.0	21	11	191	3
24B	15	0	0	0.0	12	3	400	
27	157	5	4	20.4	100	57	175	4
28	11	0	2	0.0	7	4	175	1
29	46	0	16	6.5	21	25	84	9
30A	16	0	5	18.8	9	7	129	1
31	34	1	1	2.9	20	14	143	
32	26	2	2	3.8	16	10	160	
33	1	0	4	100.0	0	1	0	3
34A	13	0	4	0.0	9	4	225	2
34B	0	0	1					
35A	17	0	10	11.8	5	12	42	8
35B	2	0	0	0.0	2	0		
38M	0	0	2					

Table 6. Black bear harvest (sport, depredation, and other) and tags sold in Arizona, 1990–2007 (AZGFD 2008).

		Harvest			
Year	Tags Sold	Sport	Depredation	Other	Total
1990	3711	149	11	1	161
1991	2843	96	4	1	101
1992	3217	121	1	0	122
1993	3329	117	1	3	121
1994	4376	236	2	14	252
1995	4586	197	1	0	198
1996	4462	254	5	19	278
1997	4093	224	2	6	232
1998	4461	142	0	13	155
1999	4163	181	0	5	186
2000	4413	320	2	46	368
2001	4293	178	6	6	184
2002	4535	230	1	16	252
2003	4525	214	5	34	249
2004	4521	160	5	11	176
2005	4850	158	0	2	160
2006	4840	197	1	40	238
2007	4968	221	1	19	241

subadult males comprised 36.3% of samples, adult females comprised 21.4% of samples, and adult males comprised 27.3% of samples.

Sex and age of annual black bear harvests are indicative of harvest rate and population trend. Management objectives target the harvest of the male segment because bears are polygynous and females are more critical to reproductive success. LeCount (1990) determined that in unhunted or lightly exploited bear populations in Arizona, adults make up 70% or more of the population, with sex ratios near 50:50 and mean ages ranging from 6–8 years. Harvest data during 1995–2007 demonstrates that mean age for both male and female bears harvested in Arizona is generally 5–6 years (Table 7).

Currently all western states use some form of the limit management system for management of black bear harvest. The Department has an annual female harvest limit that approximates 10% of the female segment of the estimated population and achieves a median age of harvested females of >5 years of age. Hunts that include only a subset of a unit also have female harvest limits to distribute opportunity and allow for a closure of specific areas when limits are achieved. Finally, population management hunts may be established to meet management objectives with goals, recommendations, or guidelines that were not met during regular seasons.

Table 7. Average and median age of harvested bears in Arizona based on tooth cementum analysis, 1995–2007.

	Average Age			Median Age		
Year	Males	Females	Total	Males	Females	Total
1995	4.2	4.9	4.4	3.5	3.0	3.0
1996	4.9	6.1	5.3	4.0	5.0	5.0
1997	4.8	7.1	5.7	4.0	6.0	5.0
1998	5.9	5.6	5.8	5.0	5.0	5.0
1999	4.7	6.1	5.4	4.0	6.0	5.0
2000	5.9	6.8	6.3	5.0	6.0	5.0
2001	6.7	6.8	6.7	7.0	6.0	7.0
2002	6.6	7.1	6.8	6.0	7.0	6.0
2003	7.1	5.7	6.6	5.0	5.0	5.0
2004	6.4	5.4	6.0	5.0	5.0	5.0
2005	4.1	4.2	4.1	3.0	3.0	3.0
2006	5.1	7.0	5.8	3.0	7.0	4.0
2007	5.0	6.5	5.6	3.0	5.0	4.0

Female Harvest Limit Management System

Arizona's bear hunt structures are designed to direct harvest toward the male segment of the bear population through the use of female harvest limits by unit or across a combination of units. The legal wildlife for all bear hunts is any bear except sows with cubs. Hunters are required to report their harvested bears within 48 hours through a toll-free hot line and hunting is closed in units where female harvest limits have been met. Closures occur at dark on the Wednesday following the report of the female limit being met.

Beginning in spring 2008, bear harvest limits were further restricted with the implementation of an annual female harvest limit, in addition to the individual season harvest limit, and includes all female bears killed by Department personnel due to human-bear conflicts. This system may close bear hunting in some units before a subsequent season is opened if the annual female harvest limit is reached before the season opens.

In a few units, the female harvest consistently exceeds the established female harvest limit (Table 8). Harvest limits are occasionally exceeded because multiple animals are harvested on a single day or within the time period in which the season remains open (seasons close on Wednesday evening).

Relative Abundance of Black Bears: Test of DNA Techniques in Units 35A and B

Arizona's female harvest limits were first established in 1992 for a few units and for all units beginning in 1995 (AZGFD Hunt Regulations 1992, 1995). Limits are based on the estimated number of females occupying habitats of high, medium, and low quality. Habitat quality is the limiting factor supporting black bear numbers, but factors such as habitat manipulation, nutrition, predation, and hunting can all be proximate regulation mechanisms (Lindzey and

Table 8. Female black bear harvest by unit in Arizona with color coding to indicate those units in which harvest limits were exceeded, 2003-2007.

	2007				2006				2005				2004				2003				2002			
Unit	Dates	Close Date	FHL	Female Harvest	Dates	Close Date	FHL	Female Harvest	Dates	Close Date	FHL	Female Harvest	Dates	Close Date	FHL	Female Harvest	Dates	Close Date	FHL	Female Harvest	Dates	Close Date	FHL	Female Harvest
1, 2ABC			4	2	8/11-8/31	8/16	3	8	na				na				na				na			
1, 2ABC	10/5-12/31		4	2	10/6-12/31		3	1	10/7-12/31		5	3	10/8-12/31		5	0	10/7-12/31		5	3	10/8-12/31		6	0
3B			3	0	8/11-8/31		2	0	8/26-12/31		7	1	8/27-12/31		7	4	8/22-12/31		7	4	8/23-12/31		7	2
3B	10/5-12/31		5	0	10/6-12/31		4	2	na				na				na				na			
3C	10/5-12/31		2	1	10/6-12/31		2	0	8/26-12/31	9/21	2	2	8/27-12/31	10/6	2	2	8/22-12/31		2	0	8/23-12/31		5	2
4A, 5A	10/5-12/31	10/10	2	5	10/6-12/31	10/25	2	2	10/28-12/31	11/2	2	3	10/29-12/31	11/3	2	4	10/24-12/31	10/29	2	7	10/25-12/31	11/6	2	6
4B	10/5-12/31		2	0	10/6-12/31		3	0	8/26-10/6		3	0	8/27-10/7		3	0	8/22-10/8	10/1	3	3	8/23-10/9		3	1
5B	10/5-12/31	10/24	1	1	10/6-12/31	10/11	1	1	10/28-12/31		1	0	10/29-12/31	11/10	1	1	10/24-12/31		1	0	10/25-12/31	10/30	1	1
6A	10/5-12/31	11/14	2	2	10/6-12/31	11/22	2	3	8/26-10/20		2	1	8/27-10/21	9/15	2	2	8/22-10/23	9/24	2	2	8/23-10/24	9/11	2	2
6B	8/10-8/30	8/22	3	3	8/11-8/31	8/30	3	3	8/26-10/20		3	0	8/27-10/21		3	2	8/22-10/23	10/22	3	3	8/23-10/24	10/9	3	3
7	na				na				na				na				na				10/25-12/31	10/30	1	1
7, 9	10/5-12/31	10/10	1	1	10/6-12/31		1	0	10/28-12/31		1	0	10/29-12/31		1	0	10/24-12/31	10/29	1	1	na			
8	10/5-12/31	10/10	1	4	10/6-12/31	11/8	2	2	8/26-10/20	8/31	1	1	8/27-10/21		1	0	8/22-10/23	9/3	1	1	8/23-10/24	9/18	2	2
9	na				na				na				na				na				8/23-10/24	9/18	1	1
10, 18A, 19B, 20AB	10/5-12/31		2	0	10/6-12/31		2	0	8/26-12/31		2	0	8/27-12/31		2	0	8/22-12/31		2	0	8/23-12/31		2	0
17AB, 18B	10/5-12/31		2	0	10/6-12/31		2	0	8/26-12/31		2	1	8/27-12/31		2	0	8/22-12/31		2	0	8/23-12/31		2	0
19A	10/5-12/31		2	1	10/6-12/31		2	0	9/2-10/20		2	0	9/3-10/21	10/20	2	2	9/5-10/23	9/10	2	2	10/25-12/31		2	0
21	10/5-12/31		2	1	10/6-12/31	10/11	2	2	9/2-10/20		2	0	9/3-10/21	10/20	2	2	9/5-10/23		2	1	9/6-10/24	9/25	2	2
22	na				na				9/2-12/31		5	2	9/3-12/31		5	2	9/5-12/31	11/12	7	7	9/6-12/31	10/23	7	7
22N	10/5-12/31		4	3	10/6-12/31	11/8	4	4	na				na				na				na			
22S	8/10-8/30	8/15	1	2	8/11-8/31	8/23	1	1	na				na				na				na			
22S	10/5-12/31		1	0	10/6-12/31	10/11	1	1	na				na				na				na			
23N	10/5-12/31	10/10	5	7	10/6-12/31		5	4	10/14-12/31	11/2	5	5	10/15-12/31	10/25	5	5	10/3-12/31		5	2	10/4-12/31		5	4
23S	8/10-8/30	8/15	2	5	8/11-8/31	8/23	2	5	9/2-12/31		5	3	9/3-12/31	9/15	5	5	9/5-12/31	10/22	5	5	9/6-12/31	9/11	5	9
23S	10/5-12/31	10/17	3	3	10/6-12/31		3	1	na				na				na				na			
24A	8/10-8/30	8/15	1	6	na				na				na				na				na			
24A	10/5-12/31	10/10	2	3	10/6-12/31		3	2	10/21-12/31		3	0	10/22-12/31		3	0	10/24-12/31		3	0	10/25-12/31		3	0
24B	8/10-8/30	8/22	1	1	8/11-8/31	8/23	1	1	8/26-9/4		1	0	8/27-9/5		1	0	8/22-9/7	9/7	1	1	8/23-9/8		1	0
27	10/5-12/31		12	10	10/6-12/31		12	9	8/26-10/6		6	4	8/27-10/7		6	4	8/22-10/6	8/27	6	9	8/23-10/7	8/28	6	7
27	na				na				10/7-12/31		15	2	10/8-12/31		15	2	10/7-12/31		15	10	10/8-12/31		15	6
28	10/5-12/31	11/7	1	2	10/6-12/31		1	0	9/16-10/20	10/15	1	1	9/17-10/21		1	0	9/19-10/23	9/24	1	1	9/20-10/24	9/25	1	1
29, 30A	10/5-12/31	10/10	3	9	10/6-12/31	10/18	4	5	9/16-10/20	9/21	4	5	9/17-10/21		4	2	9/19-10/23	9/24	4	10	9/20-10/24	10/2	4	4
31	10/5-12/31	10/10	3	5	10/6-12/31	10/25	3	3	9/16-10/20		3	2	9/17-10/21		3	0	9/19-10/23	9/24	3	3	9/20-10/24	9/25	3	4
32	10/5-12/31	10/24	2	3	10/6-12/31	10/11	2	2	9/16-10/20		2	0	9/17-10/21	9/29	2	2	9/19-10/23	9/24	2	2	9/20-10/24	10/23	2	2
FTHU/35A			1		10/6-12/31		1		8/29-12/31			0	10/21-12/31		1	0	8/22-10/23	8/27	1	1	8/23-10/24		1	0
Archery																								
1, 2ABC					9/1-10/5		2	0	8/26-10/6	9/14	3	3	8/27-10/7	9/15	3	3	8/22-10/6	9/17	3	3	8/23-10/7	9/25	4	4
3B					9/1-10/5		3	1	8/5-8/25		2	0	8/6-8/26	8/18	2	2	8/1-8/21		2	0	8/2-8/22	8/22	2	2
4B	8/31-10/4		2	0	9/1-10/5	9/27	2	1	8/5-8/25		2	1	8/6-8/26		2	1	8/1-8/21		2	0	8/2-8/22		2	0
6B, 11M	8/31-10/4	9/12	1	1	9/1-10/5		1	1	8/5-8/25		1	0	8/6-8/26		1	0	8/1-8/21		1	0	8/2-8/22		1	0
19A	8/31-10/4		1	0	9/1-10/5		1	0	na				na											
23N	8/31-10/4	9/26	2	4	9/1-10/5	9/27	2	2	8/26-9/15	9/14	2	3	8/27-9/16		2	0	8/22-9/18	8/27	1	1	8/23-9/19	9/4	1	2
27	8/31-10/4		5	1	9/1-10/5	9/13	5	5	na				na											
32	8/31-10/4		1	0	9/1-10/5	9/27	1	1	8/26-9/15		1	0	8/27-9/16		1	0	8/22-9/18		1	0	8/23-9/19	9/4	1	1
FTHU				0																				

Female Harvest Limit met
Female Harvest Limit exceeded
Units in which harvest exceeded female harvest limit at least 3 times in 6 years (50%)

Meslow 1977, Beechan 1980, Hugie 1982, Young and Ruff 1982, LeCount 1987). The productivity of a bear population is primarily related to both habitat quality and the number of adult females in the population. Removal of adult females does not increase the productivity of the remaining females (LeCount 1990).

It is important to obtain estimated numbers of female bears in similar habitats under consistent female harvest limits. New genetic methods have great potential to provide these estimates. Genetic material is currently being collected from all hunter harvested bears. Regions 5 and 6 currently have on-going pilot projects to evaluate bear abundance using hair snags and DNA analysis. The Department's Research Branch is using hair snag methodology to inventory the bear population in and around Units 35A and B. In 2008, a minimum subpopulation figure was obtained using this technique and it yielded an estimate of 35 bears. Interrelatedness determinations developed through DNA analysis will also assist in better defining future bear management areas.

Summary

1. Arizona's hunt structures are designed to direct harvest toward the male segment of the bear population through the use of female harvest limits by unit or a combination of units. Female bears with cubs are not legal for harvest.

2. New genetic methods have great potential to estimate bear abundance and are being evaluated. Regions 5 and 6 have pilot projects to evaluate bear abundance using hair snags and subsequent DNA analysis. In Units 35A and B, the preliminary results of an initial analysis indicate a minimum population of 35 bears.

3. A hunt unit cannot be closed until the Wednesday following a report of the female harvest limit being met because of logistical constraints associated with reporting requirements. If the limit on females is met on the first morning of a hunting season (routinely a Friday), the season will close on the following Wednesday. Harvest limits of female bears have been exceeded in few management units.

Management Strategies

1. Continue with the current conservative management strategy of season and annual female harvest limits to manage Arizona's bear population, while protecting females with cubs.

2. Reduce harvest of females in units that exceed annual female harvest limits on a consistent basis (e.g., 3 out of 5 consecutive years) and median age of harvested females within the hunt area is <5 years by reducing the number of seasons or shortening seasons to less than the current 6-day structures. Use DNA techniques to estimate minimum population sizes in these units.

3. Use DNA studies in conjunction with age and sex data to better estimate minimum population numbers by vegetative communities. Adjust female harvest limits for hunt areas with the best available data, including DNA-supported minimum population estimates.

4. Continue to collect genetic material from harvested bears to determine interrelatedness within broad vegetative communities. The degree of interrelatedness can be used to infer population changes within vegetative communities over time.

HUMAN-WILDLIFE CONFLICT RESOLUTION STRATEIGES

Figure 7. Mountain lion on a porch of a Tucson, Arizona residence adjacent to the Coronado National Forest, 2008.

MOUNTAIN LION

Recently, mountain lions may have increased in abundance in western United States, and have extended their range of distribution into mid-western states (deVos and McKinney 2005, Cougar Network Website 2008). Coincident with these trends, conflicts between mountain lions and humans (Figure 7), including mountain lion attacks on humans, have increased in much of western North America during recent decades (Aune 1991, Halfpenny et al. 1991, Beier 1991, Fitzhugh et al. 2003, Graham et al. 2005). Increased encounters between mountain lions and humans likely result from increased abundance of the predator, changes in prey abundance, habituation to human activity, reduced suitable habitat, and increased encroachment and recreational activities by a rapidly expanding human population within mountain lion habitats (Aune 1991, CMGWG 2005, Graham et al. 2005). Despite the increasing trend of encounters between mountain lions and humans, research on distribution and movements of the predator has focused on wilderness habitats, and factors influencing attacks. Other encounters between humans and mountain lions are poorly understood (Shuey 2005).

Human Dimensions of Mountain Lions in Arizona

Arizona's human population is expected to double to about 12 million by 2050, and the urban areas occupied within the state will continue to expand and overlap with suitable mountain lion habitat (Figure 8).

Arizona created the Mountain Lion Action Plan in 2004 to guide employee response to human-mountain lion interactions. This action plan was developed after strong public outcry to management actions that occurred in Flagstaff in 2001 and in Tucson between 2003 and 2004 identifying the lack of uniform statewide mountain lion protocol. Three public workshops (240 attendees) were conducted to elicit broad-based public input on development of the Mountain Lion Protocol. The resulting action plan categorized conflicts as sighting, encounter, incident, or attack based on acceptable or unacceptable behaviors by mountain lions. Department responses are guided by the action plan for each category. Reports are entered into the centralized Human-Wildlife Interaction Database. Since 2005, Wildlife Managers have responded to 405 mountain lion reports, of which 333 resulted in further investigative actions.

Opinions of Arizona residents towards mountain lions are important in guiding strategies to reducing human-mountain lion conflicts. In the 2005 "Attitudes Toward Urban Wildlife Among Residents of Phoenix and Tucson" survey, residents were asked whether or not mountain lions are "dangerous:" 44% agreed and 44% disagreed. Of those respondents, only 21% think that mountain lions are a threat to personal safety, while 72% believe they are not a threat. In the survey, 80% of the public accepted destroying a mountain lion that is a "threat to human safety" or is an "established threat to pets and livestock." According to Arizona residents in the survey, 33% think the mountain lion population is declining, 15% think mountain lions are endangered, 1% think they are extinct, and only 19% think the population is stable.

An Arizona Urban Mountain Lion Study

The Department studied distribution, movements, and survival of mountain lions in north-central Arizona on 1,200 km^2 near Payson, and on 4,600 km^2 near Prescott during 2006 and 2007. The objective of the studies was to determine distribution and movements of mountain lions in these hunted populations within residential-urbanized and wildland areas. Additionally we wanted to provide insights into some basic question about how mountain lions use residential-urbanized areas:

Do they enter them frequently?
Do they explore them briefly, and then leave?
Do they just move through them?
Do they use these areas as part of their normal habitats?

Eighteen mountain lions ≥2 years old were captured from these populations between January 2006 and 2007 by trailing them with hounds or using snares. Each captured mountain lion was fitted with a GPS telemetry collar equipped with a pre-programmed timed-release mechanism

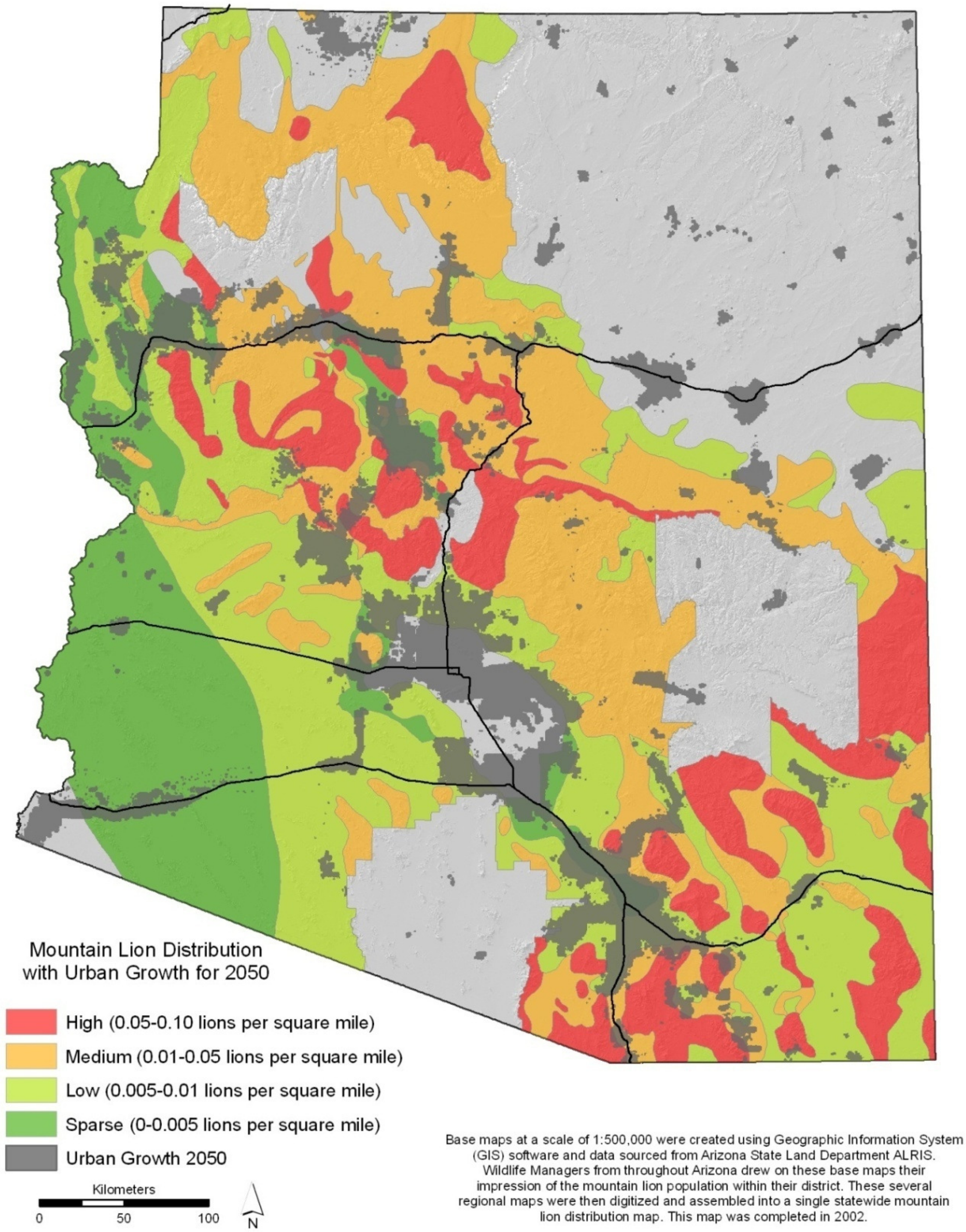

Figure 8. Estimated urban growth model for year 2050 with current estimated mountain lion abundance in Arizona. Suitable mountain lion habitat determined by comparing known mountain lion abundance within studied habitats and extrapolating this abundance across similar habitat, augmented with local biological opinion from unit wildlife managers.

and mortality-sensing option, allowing collars to be retrieved. Study animals were then immediately released. Marked animals were located continually by ground telemetry, with GPS fix location data uploaded from a fixed-wing aircraft 1–2 times per month.

Telemetry collars were placed on 18 mountain lions (5 females, 13 males) in the Payson (*n* = 6; 1 female, 5 males) and Prescott (*n* =12; 3 females, 9 males) areas that were captured ≤10 km from residential-urbanized developments. Data retrieved from collars indicated 9,651 position fixes were recorded, 2,217 for mountain lions occupying only wildland habitats (*n* = 5; 2 female, 3 male), and 7,434 position fixes for those associated with residential-urbanized areas (*n* = 12; 2 female, 10 male).

Individual mountain lions seemed to be highly variable in their use of residential-urbanized areas. Mountain lions entered some residential-urbanized areas frequently, explored some briefly and left, simply moved through some, and used others as part of their normal habitats. Despite extensive or occasional use of residential-urbanized habitats by marked mountain lions, local residents seldom reported encounters or sightings, except when an animal was killed by hunters or a vehicle. Recent research in northwestern states also suggests that mountain lions commonly encounter residential-urbanized areas.

Humans encroach upon areas occupied by mountain lions already, and the predators show remarkable ability to adapt to human presence, particularly in low-density residential areas that provide abundant stalking cover, such as brush and trees, open space, and prey like livestock, pets, and native species (Halfpenny et al. 1991, Ticer et al. 2001, Siemer et al. 2004, Shuey 2005). Speculatively, abundance of prey such as deer (*Odocoileus* spp.) and javelina (*Pecari tajacu*) has increased during recent years in some residential areas (Ticer et al. 2001, Siemer et al. 2004), possibly contributing to human-mountain lion encounters (Halfpenny et al. 1991). In Montana, habituation, food conditioning, an expanding human population, and increasing abundance of mountain lions were believed to be factors associated with increasing human-mountain lion encounters (Aune 1991).

Controversy often emerges among the public regarding mountain lions and their prey in residential and urbanized areas, requiring management interventions ranging from individual interviews and public meetings to lethal removals of mountain lions (Ticer et al. 2001, Siemer et al. 2004, Casey et al. 2005, Perry and deVos 2005). Public attitudes and knowledge about mountain lions and their management varies substantially among the public, but respondents to mail surveys in southeastern Arizona indicated their desire to maintain local populations and to manage problem animals mainly by lethal removal (Casey et al. 2005). Translocating mountain lions that display aggressive or unacceptable behavior, as defined in Department Policy I1.10, is not a viable alternative to lethal removal of problem mountain lions due to the risk of repeating problem behavior, large movements by translocated animals, a tendency for them to return to original capture areas, and high post-translocation mortality (Linnell et al. 1997, Ruth et al. 1998).

Considering problem predators in urbanized areas, men are more likely than women to accept lethal management actions, whereas women are more than men to accept nonlethal actions or a no-action approach (Siemer et al. 2004). Thus, challenges facing resource managers in attempting to mitigate human-mountain lion encounters are diverse, and lethal removal of problem animals based on objective protocols appears to be more viable than translocations. Educating the public about mountain lions remains a primary objective and need. The CMGWG (2005) and Parmer (2005) provided useful reviews of potential strategies for managing human-mountain lion conflicts. Fitzhugh et al. (2003) provided a useful review of appropriate responses of humans to encounters with mountain lions.

Options to reduce human-mountain lion conflicts in urban areas might include: 1) direct and severe warnings regarding human behavior that fosters conflicts, 2) restrictions on human use of high-risk areas, 3) removing problem mountain lions, 4) modifying habitat, and 5) deterrent methods (Fitzhugh 1988, McBride et al. 2005, Parmer 2005). Local residents generally have little familiarity with or knowledge about mountain lions (Casey et al. 2005), and severe warnings for feeding or habituating mountain lions likely will have little impact on human behavior, but should nonetheless be administered to limit liability. Lethal removal of mountain lions perceived to pose threats to humans appears to be the most practical method for mitigating negative encounters with humans if actions are based on consistent, established assessment protocols. Non-lethal methods of removing mountain lions are neither practical nor more humane than lethal methods (Linnell et al. 1997, Fitzhugh 1988, Ruth et al. 1998), although lethal methods can generate public opposition (Casey et al. 2005, Perry and deVos 2005, Treves et al. 2006).

Feeding wildlife attracts prey species to human inhabited areas and indirectly habituates lions to humans. While difficult to enforce in practice, effectively prohibiting feeding wildlife has proven to be useful and should be expanded to additional counties, cities, or portions of counties as Arizona's human population increases, urban areas expand, and high-use recreation areas interface with mountain lion habitats. Enforcement is difficult and time consuming, and partnerships with other agencies that are also responsible for enforcement should be pursued. Pets often are involved in mountain lion conflicts (Fitzhugh 1988), and education efforts targeting pet owners can reduce pet vulnerability.

Habitat modifications are impractical, because housing locations in areas with relatively extensive surrounding space, brush, and trees are attractive to humans. Research on use of residential areas by large prey of mountain lions might be informative, but public opposition for removing prey appears likely (Siemer et al. 2004). There is no available evidence that deterrent methods are successful.

Population reduction through hunting has been suggested as a means of reducing conflicts between mountain lions and humans. To be effective, a high percent of a mountain lion population would have to be reduced over a large area to limit immigration and reduce local abundance and would require continuous hunting pressure (Fitzhugh 1988). Hunting pressure is usually impossible to achieve in the urban interface where most conflicts occur because of public resistance to hunting in those areas. Increased mountain lion hunting in urban areas is unlikely to be effective in reducing human risk (Beier 1991).

Continued public town-hall type meetings, individual interviews, and clear, consistent communication with the media, combined with lethal removal, have proven to be the most appropriate approach to managing human-mountain lion conflicts (Parmer 2005, Perry and deVos 2005). We recommend that efforts to educate the public should be continual, formalized, and handled by biologists familiar with mountain lions and human-mountain lion conflicts. To address these issues, many states are currently employing large carnivore conflict resolution specialists. Brief duration and discontinuous efforts in few areas will prove ineffective for enhancing human understanding of mountain lion ecology and mitigating human-mountain lion conflicts. A well designed, science-based educational program, such as Washington State's Project C.A.T. (Cougars and Teachers) created to provide consistent messages about human-mountain lion conflicts seems desirable. The Department's Focus Wild lesson plans could be used along with this program to assist in educating the public and agency personnel.

Summary

1. Mountain lions may have increased in abundance in western United States, and have extended their range of distribution into mid-western states. Coincident with these trends, conflicts between mountain lions and humans, including attacks, increased in much of western North America during recent decades.

2. Arizona's human population is expected to double to about 12 million people by 2050, and urban growth will continue to expand into occupied mountain lion habitat.

3. Management options to prevent human-mountain lion conflicts might include: 1) direct and severe warnings for unsafe human behavior, 2) restrictions on human use of potential conflict areas, 3) removing problem mountain lions, 4) modifying habitat, and 5) deterrent methods.

4. Little is known about how or why mountain lions use residential-urbanized areas. Public outcry, controversy, and even attacks of humans or their livestock and pets indicate that encounters between mountain lions and humans are increasing throughout the west.

5. Humans encroach upon areas where mountain lions already live, and the predators show remarkable ability to adapt to human presence, particularly in low-density residential areas that provide abundant stalking cover and prey.

6. Translocating mountain lions that display aggressive or unacceptable behavior, as defined in Department Policy I1.10, is not a viable alternative to lethal control for removing problem mountain lions. Human-mountain lion conflicts are currently managed according to Department policies DOM I1.10 and 2.A.1–2.A.6, with human safety as the highest importance.

7. Typical mountain lion hunting techniques (e.g., predator calling, trailing with hounds) may be ineffective in urban settings as methods to reduce the risk of human-mountain lion encounters.

8. Continued public venue-town hall type meetings, individual outreach, and planned dialogue with the media, combined with lethal removal, have proven to be the most appropriate approach to managing human-mountain lion conflicts.

Management Strategies

1. Continue to educate the public using Department biologists familiar with mountain lions and human-mountain lion conflicts in addition to administrators, public information personnel, and outside consultants.

2. Continue to provide specialized carnivore conflict resolution training for specific personnel focused in areas where projected growth will occur and places likely to result in continued human-mountain lion interactions.

3. Invest in a science-based educational program, such as Washington State's Project C.A.T. (Cougars and Teachers), using the Department's Focus Wild lesson plans to assist in educating the public and agency personnel.

4. Continue to use Department Policy I1.10 as the guiding policy during the Department's responses to calls concerning human-mountain lion conflicts.

5. Pursue regulations prohibiting feeding of wildlife into additional counties, cities, or portions of counties as Arizona's population increases and urban areas and high-use recreation areas interface with high mountain lion density habitats. Build partnerships with other agencies that are also responsible for enforcement of wildlife feeding regulations.

6. Incorporate geospatial analyses from the collection of GPS location data at sites of investigated conflicts for improved identification with consistent conflict areas. Maintain and update all related databases.

Figure 9. Human-caused bear conflicts most often occur when bears become habituated to humans and associated food sources.

BLACK BEAR

Population estimates for North American black bear populations suggest a growth rate of about 1–2% per year (Garshelis and Hristienko 2006) since the late 1980s. America's average human growth rate increases are calculated at a rate of less than 1% per year (http://www.indexmundi.com/g/g.aspx?c=us&v=24). In the last few decades, the number of human-bear conflicts have increased dramatically (e.g., Beck 1991, Witmer and Whittaker 2001, Beckmann and Berger 2003, Zack et al. 2003, Gore et al. 2005). Urban black bear conflicts with humans may be increasing throughout North America because human development has increased the availability of human food sources to bears, development in urban areas has expanded within and adjacent to bear habitat, and black bears numbers have increased range-wide. Decker et al. (1981) suggested that high bear populations will lead to increased human-bear conflicts because of the bear's attraction to human food sources.

A Nevada study attributed many traits of urban-interface bears to the availability of human foods, including 70–90% smaller home ranges, 30% greater body mass, higher reproductive success, later denning, and slightly earlier emergence than wildland bears (Beckmann and Berger

2003*a*,*b*). Similarly in New Hampshire and New Jersey, female bears occupying habitats adjacent to human residential areas had smaller home ranges than those reported for bears in wildland areas (Ellingwood 2003, MacKenzie 2003). Bears may therefore actually thrive and increase in number adjacent to urban areas due to availability of food resources not available to wildland bears. In a recent Colorado study on human-black bear conflicts and spatiotemporal patterns and predictors, conflicts were related to agriculture (32%), followed by road kills (27%), and human development (24%) (Baruch-Mordo 2007). In Arizona, human-bear conflicts are consistently the result of habituation of bears to humans due to food resource needs (72%), road kills (24%), and agriculture (4%) (AGFD unpublished data).

Past Situation

In the last few decades, the number of human-bear conflicts have increased (e.g., Beck 1991, Witmer and Whittaker 2001, Beckmann and Berger 2003, Zack et al. 2003, Gore et al. 2005). Even so, estimates of fatal attack rates by black bears in the U.S. are 0.3 human fatalities per year, much less than the 9–15 human fatalities per year resulting from venomous snake bites (Conover et al. Twenty-three human fatalities resulted from black bear attacks in North America from the early 1900s through the 1980s (Thirgood et al. 2005). Still, risk perception of a black bear attack can increase following media coverage of an attack (Gore et al. 2005).

Wildlife managers therefore must manage black bear populations not only for sustainability and distribution but for human safety and concern for private property. Data regarding fatal attacks of humans by black bears show for 21 fatalities where the sex of bear was known, 19 involved a male bear. In all the cases where the motivation of the bear was believed to be predation and the sex of the bear was known (n = 18), the bear was male (Herrero and Higgins 1995).

In Arizona, an attack and subsequent associated media coverage occurred in July 1996 when a 340-pound, 5-year-old male black bear critically mauled a sleeping teenage girl on Mount Lemmon, 48 km north of Tucson, Arizona. The bear had been captured, ear tagged, and released within 11 km of the attack location five days prior to the attack. A lawsuit ensued and three years later, the Risk Management Section of Arizona's Department of Administration, settled for $2.5 million. The victim was permanently disfigured by the injuries. This incident defined an unacceptable limit for nuisance black bear conflicts.

Current Situation

Human-bear conflicts are currently managed in accordance to Department policies DOM I1.10 and 2.A.1–2.A.6, updated in 2006. The Department's Wildlife Conflict Policy was implemented to create a standard that defines appropriate actions to be taken when dealing with nuisance wildlife. Under the policy human-wildlife interactions are classified into one of three categories; Category I, II, and III. The policy differentiates wildlife behaviors that are acceptable from behaviors that are unacceptable or aggressive as an aid to managers handling conflict bears. These specific behaviors are offered as examples and were not intended to be all-inclusive. Managers must rely on their education, experience, training, and the individual circumstances surrounding any report when making decisions.

A Category III bear is generally defined as a bear creating a "nuisance" by its mere presence and is not judged to be an immediate threat. A Category III bear does not display unacceptable behavior (as defined in the policy), has no history of having been previously captured or relocated, and does not remain in human occupied areas. These bears often do not need to be captured or relocated (although that may depend on the circumstances), and the preferred response is to conduct public education focused on conflict prevention. A Category III bear can be any age or sex. If the bear causes repeated Category III incidents or reports, this may result in reclassifying it as a Category II or even a Category I bear.

A Category II bear is judged to pose a potential threat to public safety and health and is defined as a bear that causes property damage, is habituated to humans, conditioned to human-related food sources, is denning with cubs near human activities, displays abnormal behavior that might indicate a disease infection, or displays other unacceptable behavior. A Category II bear is limited to female bears or sub-adults (adult male bears that meet the definition in Category II are treated as Category I bears). A Category II bear may be captured and then relocated, destroyed, or an incident may be dealt with through public education. The manager on the scene or responding to a call determines the appropriate response.

A Category I bear is the most dangerous encountered by humans and is defined as a bear that poses an immediate threat to humans. More specifically, a Category I bear is defined as a bear that has caused human injury, displays aggressive behavior, or has been previously captured and relocated because of conflicts with humans. The policy states that an adult male bear, which has been captured and exhibits Category II behaviors, shall be treated as a Category I bear. The policy directs that Category I bears should be destroyed except under extenuating circumstances.

A final option for managing food-conditioned nuisance bears is providing hunter opportunity through population management hunts. These hunts have only occurred when a nuisance bear is present and hunter opportunity has no impact on public safety. To date, the Department has administered only a single population management season with five permits for bears.

The Department can also enter into agreements with other agencies or contractors to accomplish administrative removals. The Department prefers to use proactive approaches such as the Bear Aware program of information and education prior to conflict resolution. Hunter opportunity is considered an effective method of reducing or eliminating conflict bears. Recently, vegetation treatments surrounding urban areas are being investigated to determine their effectiveness in reducing bear conflicts.

Current bear hunting seasons in Arizona include both fall and spring hunt structures. In addition, the Department has available a population management hunt structure designed to manage wildlife populations to meet specific objectives of supplemental harvests of wildlife when traditional harvest strategies have not met management objectives. These alternative bear hunt strategies have given wildlife managers a full range of management choices by which to assist them in managing bears before they become conditioned to humans. By reducing the density of bears in the spring, a wildlife manager is being proactive in addressing the density and distribution of bears before summer, the peak problem bear season.

Opponents of spring hunts contend that cubs will be orphaned (Kerr 1999). Arizona prohibits the killing of females with cubs. Spring seasons routinely have fewer harvested bears than do fall hunt, and Arizona's spring archery hunts that extend through July have successfully harvested nuisance bears. Spring seasons can have less effect on bear populations than fall seasons when female limits are in place, because spring seasons are designed considering the differential den emergence dates for male and female bears (Hristienko et al. 2004). Because males emerge first, spring harvest is comprised primarily male bears.

Aversive Conditioning and Black Bears

Black bears are naturally wary and tend to avoid humans and developed areas (Mattson 1990, Clark et al. 2002, Herrero 2002). However, rapid expansion of urban areas in Arizona (Figure 10) contributes to the number of human-black bear conflicts within the state. These conflicts are likely to occur at higher frequencies after prolonged periods of drought or natural forage shortages, forcing bears to expand their home ranges in search of adequate forage (Bergersen 2001). Under these conditions bears can find urban areas attractive if alternate food sources (e.g., garbage) are not available. When bears find food in human dominated landscapes, loss of pets, localized depredation on livestock, property damage, and attacks on humans may occur (Herrero 2002).

Nuisance bears may occur in areas of marginal habitat that are enhanced by humans providing some type of artificial food source. Nuisance bears are defined by two types of behavior: habituated and conditioned (McCullough 1982, Herrero 2002). A habituated bear is an individual that has lost its fear of humans. Bears become habituated when no negative or positive outcomes arise from close proximity to humans. In other words, they continue normal activities unaffected by the presence of humans. A conditioned bear is an individual that associates a positive outcome from being in close proximity to humans (e. g., being able to acquire food). Campground bears are first habituated to lose their fear of humans and then conditioned after they learn they can get food from a close association with people. A bear's nuisance activity during a specific time of day may reflect the level of habituation and food-conditioning. An increase in daytime activity in developed areas may indicate a bear's progressively bolder conditioned and habituated behavior (Clark et al. 2002).

People often suggest that wildlife managers should "just scare bears away." Aversive conditioning is a method wildlife managers can use to attempt to alter habituated and conditioned behaviors of nuisance bears. In aversive conditioning, a wildlife manager attempts to create a negative association between a nuisance bear and humans by providing some type of negative stimulus. Some studies have found that simply trapping and immobilizing a bear and releasing it within the area of capture (on-site release) is enough to deter nuisance behaviors in bears (Brady and Maehr 1982, Wooding et al. 1988, Clark et al. 2002). Clark et al. (2002) concluded that on-site release success rates were determined by variables such as a bear's sex, presence of young, type of developed area where capture occurred, time of day the bear was active, and bear population abundance. It is not feasible for a state agency to use such a method in many cases due to the responsibility of wildlife managers to ensure some level of public safety. The six most common methods of aversive conditioning used by state agencies include 1) rubber buckshot, 2) rubber slugs, 3) pepper spray, 4) cracker shells, 5) dogs, and 6) loud noises (Beckman et al. 2004). These methods are usually deployed in conjunction with the nuisance bear being trapped and relocated away from the initial nuisance site. Until recently very little research had been conducted to test the efficacy of these non-lethal deterrent techniques.

Beckman et al. (2004) analyzed the effectiveness of three treatments on black bears in Nevada. During the study, 62 radiocollared bears were captured in urban areas in the Lake Tahoe Basin of the Sierra Nevada and randomly assigned to one of three treatment groups. The experimental treatments included: Group 1 - upon release trapped bears were hit with pepper spray, 12-gauge rubber buckshot, and a rubber slug, and exposed to cracker shells and yelling; Group 2 - upon release trapped bears were exposed to same deterrents as group 1 and chased by dogs; Group 3- (control group) trapped bears released in a silent manner with no physical or audible deterrents. A treatment's effectiveness was measured by the number of days it took for the bear to return to the area it was trapped. At the conclusion of the study Beckman et al. (2004) found that 92% of the bears returned to the initial site of capture. Of the 62 bears in the study 33 (53%) returned in less than 30 days, 17 (27%) returned between 31 and 180 days, 7 (11%) returned between 181 and 365 days, and 5 (8%) had not returned in >365 days. No difference between treatment groups was found for the mean number of days it took bears to return to the initial capture site. The researchers concluded that in the Lake Tahoe Basin, the most common nonlethal deterrents used by agencies responsible for black bear management are not effective at altering bear behavior for periods >1 month (Beckmann 2002). No evidence was provided that suggested more than immediate behavior change occurred from aversive conditioning.

Other studies evaluating efficacy of non-lethal deterrents have found similar results to Beckman et al. (2004). Weaver (2004) conducted aversive conditioning on six black bears in West Virginia and found that all of the bears resumed nuisance activities within two weeks. Hopkins et al (2006) are currently testing intensive aversive conditioning techniques at Yosemite National Park that involve capturing and collaring bears, and then following them for 168 consecutive hours applying a negative stimulus whenever the bear approached within 50 m of a human activity area. Preliminary results, with a small sample size (three), indicate the bears quickly return to developed areas (within 1–8 days) and resume unacceptable behaviors. These studies provide evidence that bear behavior is not permanently changed through aversive conditioning. Clark et al. (2002) suggested non-lethal deterrents were less effective on daylight active bears than those that are still foraging at night. This suggests that if aversive conditioning is applied to nighttime active nuisance bears, (i.e., those with less conditioned behavior) behavioral changes are more likely to occur. Any public relations benefit from aversive efforts is probably only temporary and generally results in further nuisance problems at a later date.

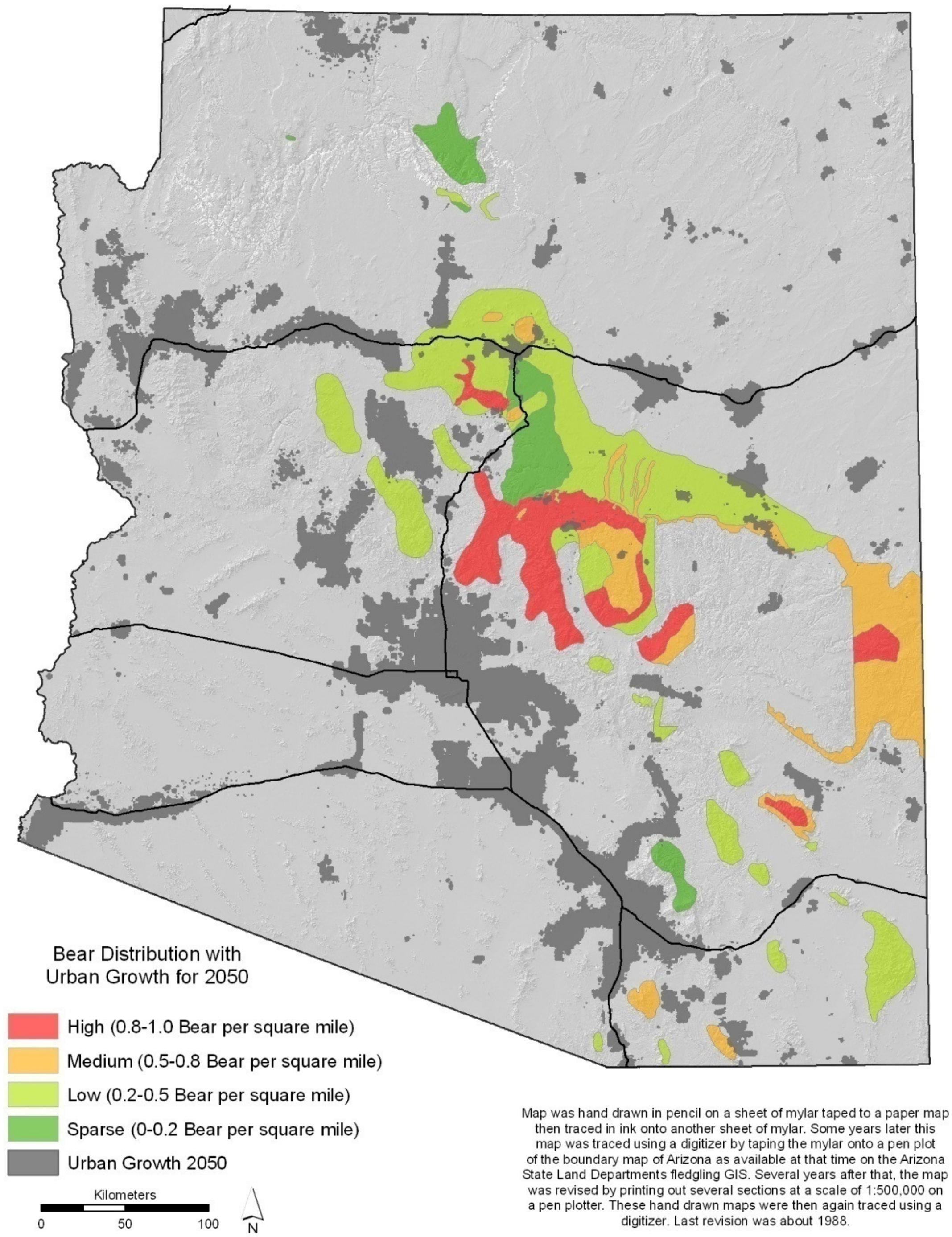

Figure 10. Interface of predicted increased human population growth in relation to distribution of black bears. Suitable bear habitat determined by comparing known bear abundance within studied habitats and extrapolating this abundance across similar habitat, augmented with local biological opinion from unit wildlife managers.

Although each of these studies concluded that aversive conditioning is largely ineffective, they do make a compelling argument for the importance of public education and outreach to prevent development of nuisance bear behavior. Gore (2004) and Herrero (2002) point out that education and prevention is the most effective method of reducing human-bear conflicts. Gore (2004) describes case studies from five different localities across North America that successfully implemented public education programs resulting in decreased human-bear conflicts. Each of the case studies employed a systematic approach to resolve nuisance bear problems. The approach included:

- Establishing a concise definition of the problem
- Defining education and intervention objectives
- Reviewing alternative options
- Identifying stakeholders involved
- Defining a target audience
- Establishing criteria that define success
- Incorporating lethal control for chronic nuisance and potentially dangerous bears

The Department's Wildlife Conflict Policy already targets human-bear conflicts with a variety of educational resources and programs. As an agency with a public safety responsibility and potential liability in some cases (especially if a bear has been captured, handled, or translocated), the Department must be prepared to address situations that can no longer be handled proactively through education and outreach. The Department must also be prepared to react to situations that would include Category I and II bears (as defined by the Wildlife Conflict Policy) that pose an immediate or potential threat to humans.

Managing Problem Bears When They Are Conditioned to the Presence of Humans

Once a bear has been conditioned to humans simply removing the food source does not eliminate the fact that the bear associates humans with food. In these cases other measures must be taken. A relocated problem bear has not regained its fear of humans and poses a potential threat to anyone it encounters at the release site. Relocating bears is not a solution, and success of a technique known as on-site release may vary (Masterson 2006). Clark et al. (2002) evaluated the technique and concluded that on-site release success rates were determined by variables such as a bear's sex, presence of young, type of developed area where capture occurred, time of day the bear was active, and bear population abundance. It is not feasible for a state agency to use such a method in many cases due to the responsibility of wildlife managers to ensure public safety.

Creating a negative association with humans is known as aversive conditioning. This method of "modifying" nuisance behavior has been a concern among researchers and wildlife managers alike due to an increased number of human-wildlife conflicts in recent years. Masterson (2006) cites the success of programs around the country using aversive conditioning to manage and curtail nuisance bear activity. She describes the successful use of Karelian bear dogs, cracker shells, rubber buckshot, and bean bags to "modify" nuisance behavior in black bears. The localized success Masterson (2006) describes is not supported by scientific literature evaluating the same aversive conditioning techniques.

Breck (2006) invented a device he called the Nuisance Bear Controller (NBC) that used two 6-volt batteries wired to an automobile vibrator coil-condenser that emitted 10,000–13,000 volts through a disk that triggers the device. The NBC appeared to have great value for protecting bird feeders. During the test period no protected feeders were robbed or destroyed by black bears, whereas 40% of unprotected feeders were robbed or destroyed. The NBC was an inexpensive ($200.00), portable, and adaptable system that potentially can be used in a variety of situations to deter bears from accessing concentrated food sources.

Generally we found the literature provided by researchers testing aversion methods suggests these techniques provide a temporary fix at best. Beckman et al. (2004) analyzed the effectiveness of rubber buckshot, rubber slugs, pepper spray, cracker shells, and dogs on black bears in Nevada. No evidence was provided that suggested more than temporary behavior change occurred from aversive conditioning. Due to these reasons and sometimes lethal results, the Department no longer uses firearm propelled aversive tools.

Vegetation Treatment to Reduce Human-Bear Conflicts

Three seasons can be distinguished in Arizona based on food habits and food resource selection patterns of Arizona bears (LeCount and Yarchin 1990): 1) hypophagia (little food consumption; 1 April to 14 June) - defined as den emergence, where black bears typically feed on carrion and herbaceous forage; 2) early hyperphagia (increased food consumption; 15 June to 31 August) - when black bears add myrmecophagy (consumption of insects) (Auger et al. 2004), and 3) late hyperphagia (1 September to denning) - defined as the period just prior to denning, when black bears seek out soft mast (acorns, fruits and berries). Since 2006, the Department has been investigating mechanisms of black bear resource selection in response to wildland-urban interface (WUI) fuel reduction timber management treatments in the White Mountains of east-central Arizona. The White Mountains are a forested landscape that have been intensively managed for >50 years. Using a quasi-experimental study design, we are testing the widely held hypothesis that forest fuel reduction plots will be avoided by black bears by examining GPS radiotelemetry data. Our specific objectives are threefold: 1) determine differences in black bear selection of fuel reduction plots; 2) describe selection by season for individual plots; and 3) examine whether there are any differences in selection of plots during diurnal or crepuscular-nocturnal periods.

The United State Forest Service (USFS) scheduled WUI fuels reduction treatments to begin in summer 2007. The purpose of the treatments was to reduce risk of wildland fire to public and private lands adjacent to focal urban areas, and to provide safety for firefighters undertaking wildland fire suppression operations. Need for this action resulted from an accumulation of natural fuels in the area. Because of fire suppression and past logging techniques, fuel loading and vegetative growth have increased and risk for fire to burn uncontrollably is high. Accordingly, WUI fuels reduction treatments will focus primarily on three key objectives: 1) decrease the amount of dead and down material on the ground; 2) increase crown base height by decreasing ladder fuels; and 3) reduce crown bulk density within the canopy. Treatment areas will be irregularly shaped and range in size from 0.1-4.4 km^2.

To date, we have placed spread spectrum GPS radiocollars on 21 (12 males, 9 females) of 35 adult bears. Radiocollars were programmed to acquire locations at intervals of every four hours. Point locations were imported into a geographic information system (GIS) and used to delineate 95% fixed kernel (FK) home ranges. These home ranges were then used to identify "available" locations for each individual using a random-point generator in ArcGIS. To account for variation in habitat use through time, we stratified black bear location data into three seasons based on food habits and selection patterns for the region (LeCount and Yarchin 1990) For each season, we developed resource selection function (RSF) models following Manly et al. (2002).

A total of 4,217 locations have been obtained and radiocollared bears have ranged from New Mexico to the White Mountain Apache Reservation. Home ranges sizes varied by sex with females averaging 77.3 km^2 (95% CI = 56.2–96.7 km^2), whereas males averaged 193.3 km^2 (95% CI = 161.8–229.4 km^2). Estimates of maximum distance moved per day varied by sex and season. During hypophagia, estimated distances moved by males ranged from 2–11 km, whereas distances moved by females ranged from 1–7 km. By late hyperphagia, distances moved by males ranged from 9–23 km, whereas distances moved by females ranged from 10–18 km.

Using data collected in 2006 and 2007, we have been able to determine how black bears use available habitat types and physiographic features prior to fuel reduction treatments. Bears appear to be very specific in the selection of habitat. Selection patterns are influenced by bear nutritional status (hypophagia and hyperphagia). As bears progressed from hypophagia through late hyperphagia, patterns of resource selection shifted from disproportionate use of meadows-grasslands to oak patches. However, it is important to note that bears consistently used mixed conifer habitats regardless of season. The consistent use of mixed conifer habitats highlights its importance to bears. Bears likely prefer mixed conifer habitats because they are often characterized by multi-story canopies, moderate slopes (>15°), and dense horizontal cover. Such habitat types appear to meet requirements for both bedding and foraging sites, particularly when located near water features (LeCount and Yarchin 1990).

As in previous studies (Lindzey 1987, Zager 1980, Young and Beecham 1986, McLellan 1998, Neilsen et al. 2002), bears displayed a strong avoidance of roads. It appears that avoidance of roads by bears is motivated by two factors: 1) general aversion to human activity and 2) effects of forest management activities that occurs at roadsides. Forest management practices that reduce structural complexity may degrade the value of habitat to bears, particularly when it occurs in mixed conifer habitats. We believe that "value" to bears occurs in two principal forms: forage availability and protective cover. When management activities reduce either, the focal habitat is degraded to some extent.

Community Involvement

Local communities have been able to eliminate bear problems by creating local volunteer outreach programs and implementing public policy regulating human behavior in bear country. An example of a successful program is Colorado's Bear Aware program. Through the Bear Aware program local citizens attend training sessions and then serve as ambassadors to the public for the Colorado Division of Wildlife. Bear Aware volunteers attend homeowner association meetings, write articles for newsletters, give talks at schools and other organizations, staff booths at county and local fairs and festivals, call on new neighbors, and generally do whatever they can to get the word out on how people can avoid conflicts with bears. Programs like Bear Aware are successful because people are more likely to listen to their neighbors than strangers.

However, some citizens do not get the message, regardless of who is delivering it, and other measures must be taken. Under these circumstances some communities have found success by enforcing policies and regulations aimed at eliminating artificial food sources. In one case study in Whistler, British Columbia, the resort town was seeing >20 bears a year being killed due to a policy that destroyed bears if they came in contact with humans. The number of bears being destroyed was a result of people's negligence and carelessness in disposal of garbage and intentionally leaving food for wildlife. In 1997, a group of Whistler citizens formed the Black Bear Task Team, which was charged with developing and implementing a bear management plan. Along with citizens, the task team included members of the resort staff, the local waste management company, the Conservation Officer Service, Whistler-Blackcomb Mountain staff, and the Association of Whistler Area Residents for the Environment. The management plan created by the team included a public education and outreach program, mandated bear proof waste management programs, and tough local regulations including:

- No garbage, food waste or other waste could be stored outdoors, including on the patio, deck or balcony.
- All outdoor trash containers had to be wildlife resistant.
- All businesses, hotels, apartment buildings and industrial complexes had to store garbage inside a building or in a wildlife resistant enclosure.
- Feeding "dangerous wildlife" and depositing or storing any "garbage, food waste or other edible waste" was illegal.
- Bird feeders had to be inaccessible to bears.
- Garbage containers for special events had to be picked up and emptied by 10 pm.

An example of the continued efforts being made by the Department to educate and inform residents concerning human-bear conflicts is the extensive work that has been accomplished in the Sierra Vista, Fort Huachuca, and Huachuca Mountain Canyons. In the last few years, the Department has made direct contact with residents in the area through packets containing information on preventing human-wildlife conflicts, initiating a community meeting at the Nature Conservancy Ramsey Canyon Preserve at which "Bear Aware" materials were distributed, and increasing wildlife manager outreach contacts with homeowners in the area. Efforts have also been made to encourage land management agencies in the area to distribute "Bear Aware" materials to campers and hikers. Since February 2006, the Department has made contact with the public at least 19 times through media outlets such as press releases, newspaper articles, and television news stories. The Department's "Living with Arizona's Wildlife" section of its website has also been promoted in virtually every public contact through the media or personal communication. However, some homeowners have not been as cooperative in eliminating food sources that lead to the conditioning of bears and ultimately to bear nuisance problems. As a result, the Department contacted the Cochise County Attorney's office and flyers were prepared and distributed to explain the legal ramifications if homeowners continued to provide attractants that promote nuisance bear activity.

Administrative Removal

In an on-going study of nuisance bears in and around Aspen, Colorado, researchers found that when wildlife managers respond to a need to remove a nuisance bear, they may accidentally capture a nontarget bear at or near the same rate as a target one (Stewart Breck, personal communication). This information was obtained from an analysis of nuisance bears radiocollared with GPS transmitters that recorded locations of the target bear every 30 minutes. Researchers could document the exact time a radiocollared nuisance bear was at a capture or complaint site. This study, when completed, may bring about changes in policies concerning how wildlife agencies confirm nuisance bears for administrative removal. Setting a bear culvert trap at a site one night and removing the captured bear the next day may not always be responsive to the original complaint.

We analyzed records for administratively killed bears in Arizona since the inception of the Department's Wildlife Conflict Policy (I1.10). Fifty-eight bears were removed by Department personnel from 15 different units (Table 9). The annual removal ranged from one to eight animals per unit, with eight bears being removed in a single year (2006) from Unit 35A, a year of suspected food source failure for bears in the Huachuca Mountains. Administrative removal of nuisance bears is effective at ensuring public safety and Department's Wildlife Conflict Policy should continue to be implemented as needed. We need to better document the exact locations of removal and record this within the database to examine trends in occurrence and identify potential causes.

Table 9. Unit and frequency of administrative removal of black bears in Arizona, 2003-2007 (AZGFD 2008).

Unit	Number of nuisance bears killed through administrative action
1	5
3B	6
3C	8
4A	4
20B	1
22	2
23	1
24A	3
27	4
28	1
29	9
30A	1
33	3
34A	2
35A	8
Total	58

Summary

1. Data regarding sex and age of black bears involved in fatal human attacks show that for 21 fatalities where the bear sex was known, in 19 cases a male bear was involved.

2. The application of hunt strategies that are focused on a controlled removal of a portion of a bear population to proactively manage human-bear interactions can be effective in reducing interactions.

3. Bears are very specific in the selection of habitats and are influenced by bear nutritional status (hypophagia and hyperphagia).

4. Human-bear conflicts are currently managed according to Department policies DOM I1.10 and 2.A.1–2.A.6, with human safety as the highest importance.

5. The most common nonlethal deterrents are not effective at altering bear behavior for periods long enough to improve public safety. No evidence suggested more than brief behavior changes resulted from aversive conditioning. Upon conducting a thorough review of published literature concerning aversive condition and nuisance black bears, it is reasonable to draw the following conclusions:

   - Aversive conditioning is not likely to result in permanent behavior modification of nuisance bears, and current research has shown it to be largely ineffective as a means to deal with nuisance bears or bears that are a threat to public safety.
   - Temporary behavior changes may occur with intensive application of negative stimulus; however implementation of this approach would be very intensive and costly, yielding questionable results.
   - Aversive conditioning may have some limited value as a public relations tool, but it is a potential liability if a bear is accidentally injured or killed during application. Privileged

THE FOLLOWING TWO BULLETS POINTS ARE CONSIDERED PRIVILEGED COMMUNICATION AND ARE NOT FOR PUBLIC DISCLOSURE

[redacted]

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6. Local communities have been able to eliminate bear problems by creating local volunteer outreach programs and implementing public policy regulating human behavior in bear country.

Management Strategies

When dealing with human-black bear conflicts there are two fundamental considerations for strategy development:

- Preventing the development of conditioned problem bears.
- Managing problem bears once they are conditioned to the presence of humans.

1. Continue with the aggressive Bear Aware program that targets communities in and adjacent to bear habitat. Enact or enforce ordinances concerning feeding wildlife and work with local municipalities to discourage planting of vegetation that attracts bears.

2. Work with local municipalities and land management agencies within areas where nuisance bear problems exist to implement waste management policies encouraging the use of bear-resistant garbage containers and evening collection times to eliminate nighttime attractants.

3. Balance the goals of maintaining viable black bear populations, protecting human safety and property, and satisfying the needs of stakeholders in a cost-effective manner. Hunting and proactive education and awareness programs are keys to achieving that balance.

4. Continue to provide specialized carnivore conflict resolution training for specific personnel because Arizona's projected growth will occur in places likely to result in continued human-bear interactions.

5. Continue to use hunt structures, including spring and population management hunts, to address nuisance bear situations adjacent to municipalities.

6. Collaborate with land management agencies to treat vegetation adjacent to municipalities within bear habitat to discourage bear habitat use within WUIs. Treat vegetation to improve bear foraging habitat, while protecting necessary screening cover, in locations away from WUIs.

WILDLIFE PREDATION STRATEGIES

Figure 11. Mountain lions are capable of killing larger prey in relation to their own body mass than any other predator, as evidenced by this attack on a mature bull elk.

MOUNTAIN LION

Of all the large felids, mountain lions kill the largest prey relative to their own body mass (Packer 1986; Figure 11). Considerable research indicates that diets of mountain lions are diverse, but few studies have demonstrated population-level impacts of predation on their prey. Mountain lions are obligate carnivores, and ungulates comprise nearly 70% of their diets in North America (Iriarte et al. 1990). In Arizona, four studies of mountain lion diet composition have been conducted; all but one (Shaw 1977) were conducted in mountain ranges inhabited by desert bighorn sheep (*O. c. mexicana* or *nelson*; Table 4; Shaw 1977, Cashman et al. 1992, Cunningham et al. 1999, McKinney et al. 2006*b*). Diet composition varied considerably among studies (Table 10). Nonetheless, predation by mountain lions in Arizona has been documented on pronghorn (*Antilocapra americana*; Ockenfels 1994), desert and Rocky Mountain bighorn sheep (*O. c. canadensis*) (Krausman et al. 1989, Bristow and Olding 1998, Kamler et al. 2002, McKinney et al. 2006*a*, McKinney et al. 2006*b*), mule deer (*Odocoileus hemionus*)

Table 10. Percent frequency of occurrence (percent of scats with prey remains) of selected prey species in diets (scats) of mountain lions in Arizona (sources: Shaw 1977[a], Cashman et al. 1992[b], Cunningham et al. 1999[c], McKinney et al. 2006*b*[d]).

Remains of prey species	Percent frequency of occurrence (%)
Mule deer	54[a] 39[b] 48[c] 9–18[d]
Javelina	2[a] 25[b] 17[c] 14–60[d]
Cattle	26[a] 13[b] 34[c] 0–14[d]
Rodents	8[b] 4[c] 0–9[d]
Lagomorphs	2[a] 8[b] 6[c] 9-33[d]
Desert bighorn sheep	7[b] 2[c] 2–22[d]
Pronghorn	2[a]

(Shaw 1977, Mattson et al. 2005), elk (*Cervus elaphus*), badger (*Taxidea taxus*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), and smaller mammals, including porcupines (*Erethizon dorsatum*), javelina (*Dicotyles tajacu*) (Cashman et al.1992), and lagamorphs (Mattson et al. 2005).

In several cases, mountain lion predation appears to have hampered efforts to translocate desert bighorn sheep in Arizona, Colorado, New Mexico, Texas, and Utah (Krausman et al.1999, Rominger et al. 2004, McKinney et al. 2006*a*). Factors affecting predation of translocated desert bighorn sheep are poorly understood, but a relative scarcity of mule deer may be involved (Rominger and Weisenberger 1999, Logan and Sweanor 2001, Kamler et al. 2002, Rosas-Rosas et al. 2003, Holl et al. 2004, McKinney et al. 2006*a*). Predation on bighorn sheep by mountain lions may be independent of the relative abundance of sheep (Ross et al. 1997), bighorn sheep habitat quality (Wakeling and Riddering 2007), or relative abundance of mountain lions (Logan and Sweanor 2001, McKinney et al. 2006*a*).

Mountain lion predation on bighorn sheep is highly sporadic and varies spatially and temporally. Although several studies have suggested the relative importance of mountain lion predation as a limiting factor in bighorn sheep populations, research on bighorn sheep population-level impacts is limited. Importantly, our understanding of population-level impacts of mountain lion predation on bighorn sheep has been hampered by an almost exclusive study of bighorn sheep populations already perceived to be declining. The potential for mountain lion predation to have a population-level effect appears highest in small (<100) sheep populations inhabiting desert environments (Sawyer and Lindzey 2002). Some research suggests that mountain lion predation contributed to Rocky Mountain bighorn sheep population declines at higher latitudes in North America (Festa-Bianchet et al. 2006). Other studies suggest that relative abundance of mule deer is a factor influencing mountain lion predation in desert bighorn sheep populations because mountain lions shift to other prey species when mule deer become less abundant (Kamler et al. 2002, Holl et al. 2004, McKinney et al. 2006*a*). Some researchers hypothesized that free-ranging cattle "subsidized" mountain lions, allowing maintenance of mountain lion populations at higher numbers, thereby increasing predation on desert bighorn sheep (Rominger et al. 2004). Decisions to conduct lethal removal of mountain lions to benefit desert bighorn sheep populations often result in public controversy (McKinney et al. 2000, Rominger 2007).

Lethal removal of mountain lions from a study area in Unit 22 in central Arizona corresponded with reduced predation by mountain lions, ended a protracted population decline, and increased abundance of desert bighorn sheep, despite successive years of drought (McKinney et al. 2006*b*). Relative abundance of desert bighorn sheep also corresponds with rainfall levels (McKinney et al. 2001, McKinney et al. 2006*b*). Higher levels of rainfall in desert systems lead to more abundant forage production, and neither food shortages nor predation likely act alone as limiting factors (McNamara and Houston 1987, Marshal et al. 2005, McKinney et al. 2006*b*).

Predator control is controversial (Ballard et al. 2001), but localized, short-term, case-by-case removal of mountain lions to benefit some desert bighorn sheep populations may be a viable management prescription. But in the absence of specific limits, hunt and depredation harvests likely are inadequate to affect abundance of mountain lions and reduce predation in areas where the predators are sympatric with desert bighorn sheep (McKinney et al. 2006*a*, McKinney et al. 2006*b*). Research suggests that lethal removal of relatively few mountain lions annually may benefit growth, productivity, and persistence of small, isolated desert bighorn sheep populations regulated by predation (Wehausen 1996, Ernest et al. 2002, McKinney et al. 2006*b*). However, persistence of short-term benefits of predator control efforts for desert bighorn sheep populations, and duration and frequency of predator control necessary to maintain such benefits, are unknown.

Research suggests that mountain lion predation does not cause mule deer population declines, but might suppress populations when they are below forage carrying capacity. Moreover, weather, human use patterns, number and type of predator species, and habitat alterations also influence predator-prey relationships (Ballard et al. 2001). Unfortunately, forage carrying capacity is largely a qualitative concept and difficult to measure. Most variables potentially affecting mountain lion-prey relationships can be difficult to quantify in terms of cause and effect.

Modeling research suggested that mountain lion predation was a minor factor in decline of a mule deer population in Idaho and did not suppress recovery of the population (Laundré et al. 2006). However, in British Columbia, mountain lion predation may have contributed to lower survival of mule deer (Robinson et al. 2002). Other research suggests that abundance of mule deer was a limiting factor affecting mountain lion populations (Laundré et al. 2007). Reduced abundance of mountain lions and predation may be associated with increased abundance of mule deer in an area of Utah (Ripple and Beschta 2006). Although somewhat controversial, research indicated that abundance of mountain lions may be regulated by social patterns among mountain lions. Associations between mountain lion and mule deer abundance may be influenced or limited by environmental variables other than abundance of prey alone (Hemker et al. 1984, Lindzey et al. 1994, Pierce et al. 2000).

Rainfall patterns may be the key factor influencing abundance of mule deer in arid regions (Wakeling 2001, Marshal et al. 2002, Lawrence et al. 2004, Bender et al. 2007). In more northern regions of North America, mountain lions prey on both mule and white-tailed deer (*Odocoileus virginianus*), but appear to select mule deer (Robinson et al. 2002, Cooley et al. 2008). Mule deer in California may reduce their risk of predation by selecting specific habitat characteristics (Pierce et al. 2004). Recent research indicates that a male mountain lion and a female with kittens may kill 19–44 and 40–73 mule deer each year, respectively (Laundré 2005).

Wolves may displace or reduce abundance of mountain lions in sympatric ranges. Wolves recently were reintroduced into northeastern Arizona (Ballard et al. 2000). Wolves and mountain lions both prey on deer and elk (Alexander et al. 2006, Atwood et al. 2007), wolves may kill mountain lions and usurp prey carcasses from them (Kortello et al. 2007), and wolves may cause deer and elk to shift to more structurally complex refuge areas, increasing availability of prey for mountain lions (Atwood et al. 2007).

As mountain lion distribution has expanded, conflicts between mountain lions and other wildlife have increased. Mountain lions have been documented in the harshest of environments along the western border of Arizona at an occupancy level that recently necessitated adaptive management actions. Some mountain lions were removed from areas inhabited by declining populations of desert bighorn sheep. Nine areas with translocated sheep or declining sheep or pronghorn populations have multiple bag limits to encourage site-specific sport harvest by hunters (no area has yet reached its limit). In the 2005 "Attitudes Toward Urban Wildlife Among Residents of Phoenix and Tucson" survey. When asked about controlling mountain lions, 65% of the public found it acceptable "to protect endangered or threatened wildlife" and 55% found it acceptable "to protect wildlife populations that are declining." However, less than 50% found it acceptable "to increase numbers of big game animals."

Mountain lion-prey relationships are complex and likely involve interactions between abiotic and biotic variables that can be difficult to quantify. Little research has clearly demonstrated population-level impacts of mountain lion predation on desert bighorn sheep, mule deer, or white-tailed deer, and none has shown population-level impacts on elk. These ungulates, as well as javelina and pronghorn, are mountain lion prey in Arizona, but few studies have assessed diet composition of mountain lions. Potential population-level impacts of mountain lion predation have been studied only for desert bighorn sheep. Justifying lethal removal of mountain lions to benefit ungulate populations will be vulnerable to criticism without further understanding of population-level impacts of predation and factors that influence predation.

Currently in Arizona, mountain lions are managed to minimize adverse impacts on other wildlife species. This is accomplished through the Arizona Game and Fish Commission Predation Management Policy, which states: "Actions by the Arizona Game and Fish Department (department) should be based on the best available scientific information. Mountain lions and coyotes will be managed to ensure their future ecological, intrinsic, scientific, educational, and recreational values, to minimize conflict with humans, and to minimize adverse impacts on other wildlife populations."

The Department develops site-specific predator management plans when mountain lions are considered to be inhibiting the ability of the Department to attain management goals and objectives for other wildlife species. Furthermore, the Department's Predator Management Team

Report states that; "Predators and their prey cannot be managed separately" and that "as a Department we must strive to develop the biological and social data necessary to manage predators with a program that is biologically sound and publicly acceptable." There are currently two predator management plans that address mountain lion removals for the Black Mountains and Kofa National Wildlife Refuge. The Black Mountain Plan uses a desert sheep survey rate as a management trigger for removal of mountain lions while the Kofa Plan uses an offending lion definition of more than one desert sheep killed by a mountain lion in a six month period. Removals have been facilitated using contract lion specialists. The combined use of a predator management plan and individuals knowledgeable of lion capture methodology is highly recommended.

BLACK BEAR

Black bears are opportunistic predators and have been documented as predators of a variety of wildlife species, large and small. Few studies have documented black bears as limiting other wildlife species or an additive mortality factor. Black bear predation has been documented on moose (*Alces alces*) in Alaska (Osborne et al. 1991) and woodland caribou (*Rangifer tarandus caribou*) in Newfoundland (Mahoney et al. 1990). In Arizona, predation by black bears on other species of wildlife has been sparsely documented, is poorly understood, and is not well researched. In central and east-central Arizona, analyses of bear scats showed that diet composition was <0.5% elk, mule deer, white-tailed deer (*Odocoileus virginianus*), and javelina (LeCount 1984, 1990; Cunningham personal communication). Black bears are not considered a limiting or major predator of any wildlife species that inhabit Arizona. Therefore, we offer no strategy for managing wildlife predation by black bears.

Summary

1. Lethal removal of mountain lions from a study area in central Arizona corresponded with reduced predation by mountain lions, ending a protracted bighorn sheep population decline, and increased abundance of desert bighorn sheep, despite successive years of drought.

2. Little research has clearly demonstrated population-level impacts of mountain lion predation on mule or white-tailed deer, and none has shown population-level impacts on elk.

3. Mountain lion predation on bighorn sheep seems to be higher in areas of lower mule deer abundance.

4. Hunter harvests alone have not been increased adequately in small areas (i.e., multiple bag limit areas) inhabited by bighorn sheep to affect predator abundance.

5. Black bears are not considered a limiting factor or major predator of any wildlife species that inhabit Arizona and therefore we offer no strategy for managing wildlife predation by black bears.

Management Strategies

1. Continue to use site-specific predation management plans as directed through the Commission's Predation Management Policy to address situations where other wildlife species have been recently translocated or where the other wildlife species is below population management objectives.

2. Evaluate the need to expand the geographic area of site-specific predator management plans on a regional basis where mountain lions are the identified predator of management need and adverse impacts on wildlife populations are documented. Develop and evaluate broader regional predation management plans where other wildlife species objectives have not been met and predation is a contributing factor.

3. Continue to use multiple bag limits to provide increased hunter opportunity within hunt areas where increased removal of mountain lions may benefit prey species that are below management objectives. Multiple bag limits may allow the targeted removal of specific animals through hunter harvest.

4. Continue to use Department or contract personnel trained in capture methods to remove mountain lions in areas identified in predator management plans.

5. Intensive harvest of female mountain lions in an area could theoretically reduce mountain lion predation on wildlife because male mountain lions may spend less time in areas with fewer breeding females. Implementation of this strategy should be experimental and adaptive to test efficacy of approach.

LIVESTOCK DEPREDATION STRATEGIES

Figure 12. Although mountain lions comprise 90% of all depredation harvests in Arizona, they may also scavenge a cow carcass that they did not kill (photo by Brian Jansen).

MOUNTAIN LION

Take of mountain lions involved in livestock depredation is authorized through Title 17 of the Arizona Revised Statutes (2007), subsection 17-302. Confirmed legal depredation harvests of mountain lions in Arizona were recently analyzed across a 30-year period (1976–2005) to describe patterns, trends, and demographics of depredation harvest, and determine relationships between depredation harvest, sport harvest of mountain lions, and indexed the abundance of mule deer (McKinney and Wakeling in press). Depredation harvest of mountain lions increased, contributed substantially to statewide harvest of mountain lions, and was negatively correlated with abundance of mule deer. Mountain lions have also been known to scavenge dead livestock (Figure 12).

Harvest of mountain lions for cattle depredations comprised 90% of all depredation harvests between 1976 and 2005; 98% of cattle depredations were calves. Most depredation harvests occurred between January and June (Figures 13, 14), when calves tend to be born. Harvests for depredations of livestock other than cattle were proportionally low and showed no clear monthly pattern, although they appear higher during June–July than other months (Figure 14). Harvests of mountain lions for cattle depredations averaged 26.7/year (range = 1–66/year), and

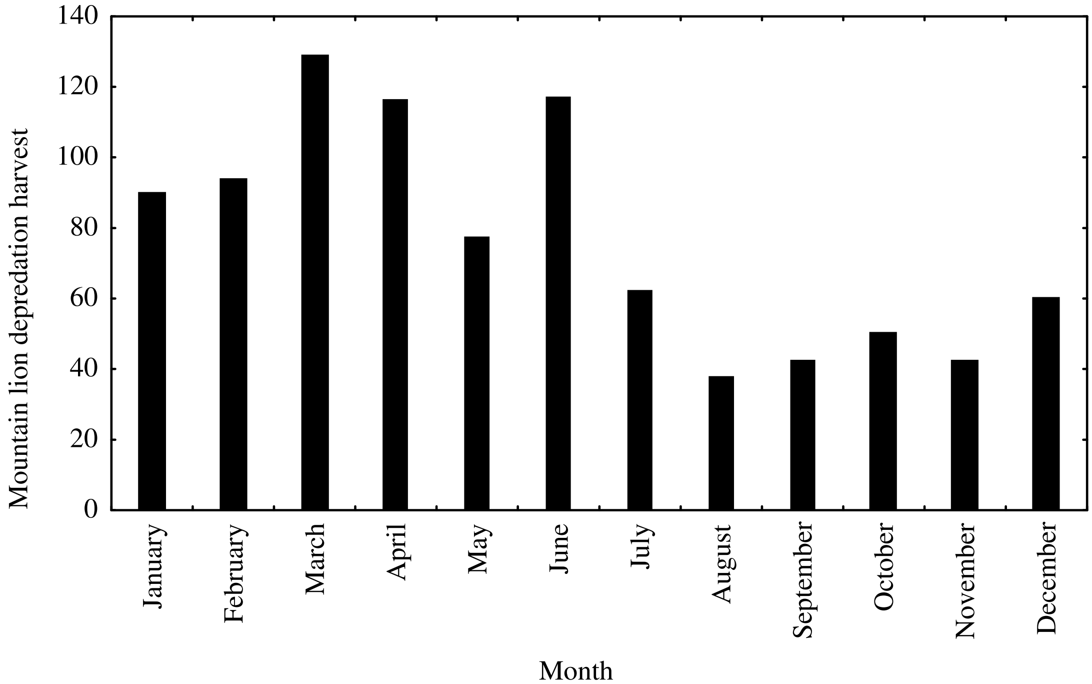

Figure 13. Number of mountain lions harvested in Arizona for depredation of livestock by month during 1976–2005.

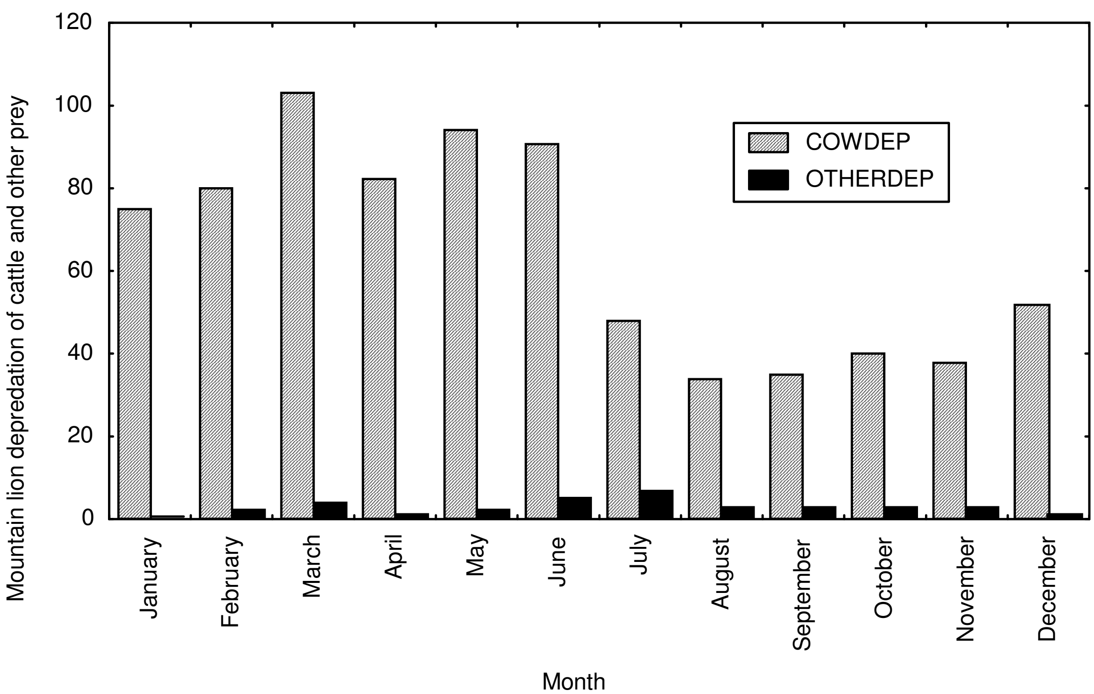

Figure 14. Number of mountain lions harvested in Arizona for depredation of cattle (COWDEP) or other livestock (OTHERDEP) by month during 1976–2005.

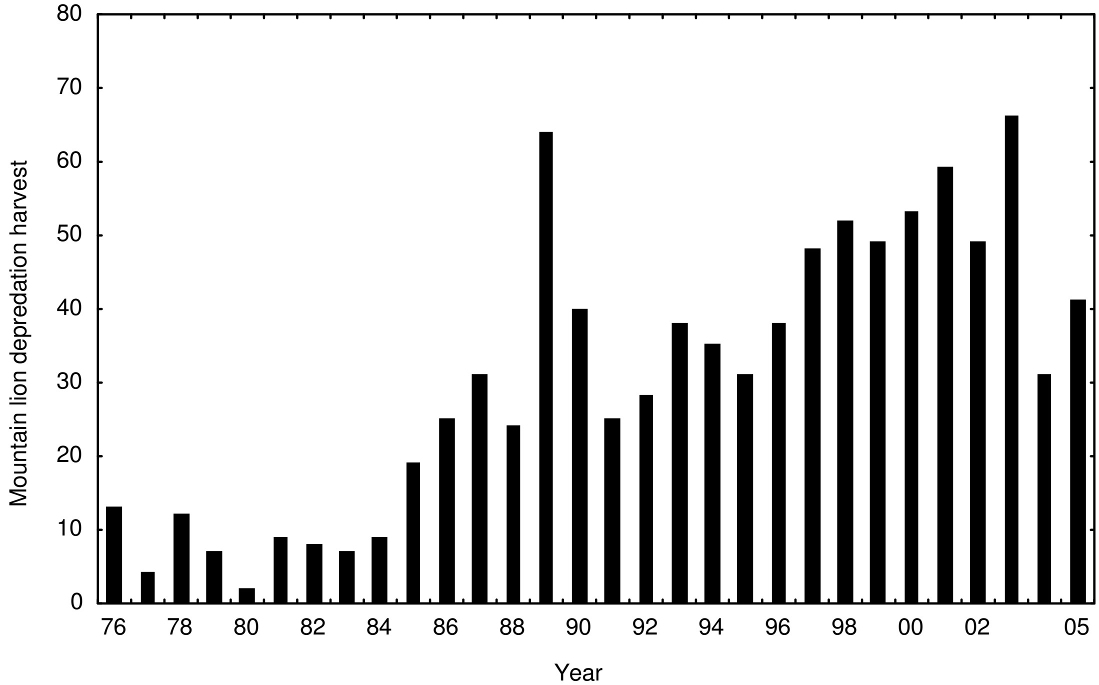

Figure 15. Annual cumulative frequency of mountain lion depredation harvest in Arizona, 1976–2005.

harvests for depredation of other livestock species averaged 1.0/year (range = 0–3/year). Depredations of prey other than cattle included chickens, colts, domestic dogs, goats, sheep, and ostriches (llamas also reportedly have been killed by mountain lions, but this species did not appear in our records).

Harvest of mountain lions involved in cattle depredation occurred in 12 of 15 counties; five contiguous counties accounted for 92% of depredation harvests. Depredation harvests associated with cattle in these five counties were: Mohave (6.3%), Yavapai (6.5%), Gila (7.7%), Greenlee (24.2%), and Graham (47.6%) counties. Total depredation harvests of all mountain lions, all adults, adult females and males, and all subadults were negatively correlated with indexed abundance of mule deer (hunter harvest), which declined during 1976–2005 (McKinney and Wakeling in press). Mountain lions appear to prey on cattle more frequently when mule deer populations decline.

Many wildlife management agencies in western states consider depredation of livestock and other domestic animals by mountain lions an important management concern (Ballard et al. 2001, Torres et al. 1996, Barber 2005, Winslow 2005, Woolstenhulme 2005). But, predator reduction to minimize domestic livestock loss or to benefit wildlife populations is a controversial action for wildlife management agencies (Ballard et al. 2001). Predator control efforts in Arizona between 1947 and 1969, when the state legislature offered a bounty on mountain lions, resulted in 5,400 mountain lions killed (Phelps 1989). In 1970, mountain lions were classified as big game in Arizona; harvest of mountain lions for reported depredations of livestock began in 1971 (AZGFD 2006). Depredation harvests of mountain lions in Arizona has increased since 1985 (Figure 15).

Livestock depredation by mountain lion can be documented. Depredations of cattle by mountain lions occur in 11 western states, but are highest in Arizona (Shaw 1983, Cunningham et al. 1995, Cunningham et al. 2001, Mountain Lion Foundation 2007). About 850 livestock operators presently graze 56,000 cattle on public lands in Arizona (Bureau of Land Management 2006; *blm.gov/az/range.htm*). Calves comprised about 93% of cattle killed by mountain lions on a ranch in north-central Arizona (Shaw 1983). Calves comprised 34% of diets and 44% of biomass eaten by mountain lions in southeastern Arizona (Cunningham et al.1999). Other studies in Arizona reported 13% (Cashman et al. 1992), 14% (McKinney et al. 2006*b*), and 26% (Shaw 1977) occurrences of cattle in diets of mountain lions (Table 10).

Hunter harvest is considered the primary cause of adult mountain lion mortality in hunted populations (Ruth et al. 1998, Logan and Sweanor 2001). However, depredation take may exceed hunter harvest of mountain lions in portions of Arizona (Cunningham et al. 1995, Cunningham et al. 1999, Barber 2005). Depredation harvest was the primary cause of mountain lion mortality in southeastern Arizona (Cunningham et al. 2001) and accounted for 15% of all mountain lions harvested in Arizona between 1996 and 2004 (Barber 2005). Depredation harvest of mountain lions in Montana increased between 1971 and 1990 (Aune 1991). Depredation incidents involving mountain lions increased in California in the absence of legal hunting between 1972 and 1995 (Torres et al. 1996).

About 92% of depredation harvests occurred between 1985 and 2005, when they comprised 18% of hunter harvest of mountain lions. Adult males were harvested for depredations more frequently than adult females or subadults of either sex, consistent with previous findings (Aune 1991, Torres et al. 1996; Linnell et al. 1999; Cunningham et al. 2001; Woolstenhulme 2005). Mean sex ratio (M:100F) of depredating mountain lions killed (136:100) was higher than the average (114:100) for mountain lions harvested by sport hunting in Arizona between 1982 and 2002 (Zornes et al. 2006). Sex ratio also reportedly favored males (M:100F = 148:100) for depredating mountain lions in California (Torres et al. 1996). Explanation for the tendency of males to predominate in depredation harvest is uncertain (e.g., larger body size of males may facilitate taking larger prey), but greater vulnerability of males to methods of depredation harvest is unlikely (Linnell et al. 1999).

Depredation harvest of mountain lions among 36 units in Arizona between 2003 and 2007 (Table 1) totaled 200, ranged from 0 to 61, averaged 17.6% of hunter harvest, and occurred at some level in 12 units (Table 1; mean harvest = 13.3/unit ±19.7). Highest levels of depredation harvest (32–61) occurred in Units 28, 31, and 32, more moderate levels (9–22) occurred in Units 17A and 17B, 18A and 18B, and 27; lowest depredation harvests (1–3) occurred in Units 19A and 19B, 20A, 20B, and 20C, 24A and 24B, 29, and 36A, 36B, and 36C. The remaining 24 units had no depredation harvests. A population sink due to the additive affect of depredation harvests may occur in Units 27, 28, 31, and 32 (Cunningham et al. 2001). These units have a full-time USDA Wildlife Services mountain lion hunter employed to respond to depredation reports.

Mountain lions occupy various habitat types throughout Arizona and inhabit about 187,000 km^2 of suitable habitat that includes about 31,000 km^2 classified as high quality habitat (Barber 2005). Five counties that comprised about 35% of occupied habitat accounted for 92% of depredation harvests for predation of cattle during 1976–2005. These counties essentially are contiguous with the northwest-southeast distribution of the chaparral zone in Arizona (Swank 1958). Vegetation consisting of Great Basin conifer and Madrean evergreen woodlands, Rocky Mountain and Madrean montane conifer forests, and Arizona Upland Sonoran Desert scrub also is contiguous with chaparral in much of the region (Brown 1994). Most reports of depredations of cattle by mountain lions in Arizona originate from mid-elevation chaparral and pine (*Pinus* spp.)-oak (*Quercus* spp.) woodlands, with few documented in high-elevation or low desert areas (Shaw et al. 1988, Cunningham et al. 1999).

Relationships between livestock husbandry practices and mountain lion depredations have not been adequately demonstrated (CMGWG 2005). Nonetheless, depredation of cattle by mountain lions is likely higher if free-ranging cow-calf herds are grazed in areas of rugged terrain and dense vegetation cover and if abundance of prey other than cattle is comparatively low (Shaw 1983, Cunningham et al. 1999, Bueno-Cabrera et al. 2005).

Yearlong cow-calf operations predominate in mountainous areas of many counties. Historically intensive mountain lion depredation control efforts in some regions of Graham County is emblematic of that relationship (Dodd and Brady 1986, Cunningham et al. 2001). Between 1988 and 1993, hunters and depredation control efforts removed 32 and 26 mountain lions, respectively, from a portion of Graham County (Cunningham et al. 2001). Another 46 and 52 mountain lions were removed from the area between 2000 and 2005 by hunters and depredation control, respectively (AZGFD 2005, AZGFD 2006).

Depredations of livestock concern ranchers and wildlife managers alike, but killing depredating mountain lions may provide only a short-term solution for preventing or reducing losses of cattle (CMGWG 2005, Graham et al. 2005). Intensive levels of sport harvest of mountain lions may alter demographics and reduce populations, but populations appear to recover relatively rapidly if hunting pressure is not maintained over time (Lindzey et al. 1992, Ross and Jalkotzy 1992, Cunningham et al. 2001, Anderson and Lindzey 2005, Stoner et al. 2006).

Intensive, localized harvest of mountain lions in suitable habitat (such as may occur in a cattle operation with intensive predator control) may create a "sink," where abundance may be maintained by emigrations from surrounding habitats (Cunningham et al. 2001). Longer term solutions to depredation might require significant reductions in mountain lions over broad areas or modification of cattle husbandry practices, such as removing calves from prime mountain lion habitat (Shaw 1977, Shaw et al. 1988, CMGWG 2005). Research is particularly needed to evaluate effectiveness of different animal husbandry practices in reducing livestock depredations (CMGWG 2005). Moreover, removing depredating mountain lions has not reduced cattle depredation rate in Arizona.

Potential explanations for increased depredations by mountain lions in western U.S. are speculative, but include factors such as changes in land use, elimination of bounties, increasing abundance of mountain lions, and declining abundance of deer (CMGWG 2005). Mule deer are the primary prey of mountain lions in North America (Iriarte et al. 1990), and are widely distributed in Arizona (Hoffmeister 1986). Abundance of mule deer might be a factor influencing abundance of mountain lions (Hemker et al. 1984, Lindzey et al. 1994, Pierce et al.

2000, Riley and Malecki 2001). Availability of natural prey might influence depredation of cattle by mountain lions (Polisar et al. 2003). Our findings suggest that decline in abundance of mule deer corresponded with increased depredation harvests of mountain lion in Arizona.

Reducing Depredations on Livestock by Mountain Lions and/or Shift Depredation Harvest into Hunter Harvest

Between 2003 and 2007, 83% of mountain lions killed for cattle depredations were harvested in Graham and Greenlee County in Units 27, 28, 31, and 32 where USDA Wildlife Services currently employs two full-time mountain lion hunters. Multiple bag limit areas for mountain lions presently occur in areas with substantial depredation harvests only in Unit 27, in Greenlee County. During 2003–2007, depredation harvests in this unit and county represented only 11% of statewide mountain lion depredation harvests. Sport harvests in this area during 2005–2007 (n = 13), when the multiple bag limit was in place, was lower than during the three-year period (2002–2004; n = 40) just prior to initiation of the multiple bag limit. Depredation harvests also declined 57% from 2002–2004 (n = 21) and 2005–2007 (n = 9). The hunter harvest sex ratio between these respective periods increased from 74 M:100 F (17 M, 23 F) to 160 M:100 F (8 M, 5 F).

Longer term solutions to depredation might require significant reductions in mountain lions over broad areas, or modification of present husbandry practices, such as grazing cattle in mountain lion habitats when calves are present (Shaw 1977, Shaw 1988, CMGWG 2005). Research could evaluate the effectiveness of different animal husbandry practices in reducing livestock depredations (CMGWG 2005). Moreover, removing depredating mountain lions has not been shown to reduce subsequent cattle depredations, although depredation harvests potentially contribute substantially to total annual harvest of the predator.

Intensive harvest of female mountain lions in an area, even though females are responsible for comparatively fewer cattle depredations than are males, may reduce mountain lion depredations on cattle because the reduction in female numbers may result in male mountain lions seeking other habitats where mates are more readily available. Correspondingly, relative abundance of male mountain lions, although ostensibly associated positively with abundance of mule deer, might be affected by relative abundance of potentially sexually receptive female mountain lions in an area.

Management actions can be tested to determine if a change in cattle depredation patterns could be detected. Experimentally, an increased harvest limit for females may be tested to determine if selective harvest of females by contract hound hunters would reduce cattle depredations. This could be tested experimentally (adaptive management) by imposing a high female sport harvest limit (multiple bag limit) in some units for a period of ≥5 years, followed by restricted female harvest (e.g., no female harvest) over the subsequent ≥5 years. Alternatively, various units could be assigned simultaneously to high or low female harvests. Comparison of cattle depredation harvests between these periods of differential female harvests would provide assessment of effects of intensive female harvests on mountain lion cattle depredation rates.

Significant and widespread conflicts between humans and large carnivores arise due to depredations of livestock, resulting in predator removals in response to depredations (Linnell et al. 1999). Surveys suggest that the public can be polarized in their opposition to or support for removal of predators that threaten livestock or other domestic prey (Casey et al. 2005). However, implementing the experiment outlined above coincident with public involvement might be feasible from an adaptive management perspective. Regardless, this experimental assessment likely is an untenable approach for managing depredations of cattle by mountain lions in Arizona unless the Department chooses to commit long-term to involvement in predator control efforts for livestock. This management approach may not be desirable.

BLACK BEAR

We analyzed depredation harvests of black bears for a fifteen-year period between 1990 and 2005 throughout Arizona to describe patterns, trends, and demographics of depredation harvest, and determine relationships between depredation harvest and sport harvest of black bears. We used 1990 as the starting point for our analysis because the state law that permits livestock owners to protect their property from depredating bears (A.R.S. § 17-302) was significantly changed in 1990 to require reasonable evidence of attacks on livestock recently if a person authorized by the Department requests such evidence. Prior to 1990, scavenging black bears caught and killed in traps set for depredating mountain lions may have been reported in the depredation harvest. Beginning in 2006, hunters were permitted to kill depredating black bears (and mountain lions), keep the carcass and report it in the hunter harvest.

Black bears are omnivores and their scavenging of livestock carcasses may put them at risk of being inappropriately blamed for livestock mortality. In a food habits study by LeCount et al. (1984) in central Arizona, the frequency of occurrence of cattle in the diet of black bears was 0.4 percent. In a second food habits analysis of black bears in east-central Arizona by LeCount and Yarchin (1990), the presence of livestock in scats was not detected.

The black bears killed for livestock depredation during the period analyzed were mostly males, were taken during the months of May–July, averaged 2.7/year (range = 0–11/year), and did not contribute significantly to the statewide harvest of black bear (about 1%) (Table 11). As with mountain lions, the killing of black bears for livestock depredation is currently occurring in Greenlee and Graham counties where Wildlife Services have contractual agreements with the county and livestock associations to employ government depredation hunters.

Relatively little livestock depredation occurs as a result of black bear activities and no change may be needed to manage black bears effectively.

Table 11. Summary of Arizona bear hunter harvest, tags sold and depredation harvest, 1990–2005.

Year	Tags Issued	Hunter	Depredation	Total
1990	3,711	149	11	160
1991	2,843	96	4	100
1992	3,217	121	1	122
1993	3,329	117	1	118
1994	4,376	236	2	238
1995	4,586	197	1	198
1996	4,462	254	5	259
1997	4,093	224	2	226
1998	4,461	142	0	142
1999	4,163	181	0	181
2000	4,413	320	2	320
2001	4,293	178	0	178
2002	4,535	230	6	236
2003	4,525	214	1	215
2004	4,521	160	5	165
2005	4,850	158	0	158
Total	61,528	2,977	41	3,016

Summary

1. Cattle depredation harvest comprised 90% of all depredation harvests between 1976 and 2005; 98% of cattle depredations were of calves. Most depredation harvests occurred between January and June when calves tend to be born.

2. Depredation harvests of mountain lions, particularly for predation on cattle, increased between 1976 and 2005, and has contributed substantially to total harvest since 1985.

3. Depredation harvests involved primarily predation of calves by adult male mountain lions. Five counties accounted for 92% of mountain lion depredation harvests during 1976–2005.

4. During 2003–2007, 83% of depredation harvests occurred in only two counties, reflecting a lack of depredation harvests in Gila, Mohave, and Yavapai counties when compared to the 1976–2005 study.

5. Negative correlation between indexed abundance of mule deer and harvest of mountain lions for depredations during 1976–2005 is consistent with a hypothesis that abundance of the ungulate influences mountain lion depredations of cattle. When natural prey is less abundant, mountain lions shift their diet to include more cattle.

6. Black bears killed for livestock depredation during the period analyzed were mostly males, during the months of May–July, averaged 2.7/year (range = 0–11/year), and did not contribute significantly to the statewide harvest of black bear (about 1%).

Management Strategies

1. Intensive harvest of female mountain lions in an area, even though they are responsible for comparatively fewer cattle depredations than are males, could theoretically reduce mountain lion depredations on cattle because male mountain lions may spend less time in areas with fewer breeding females. Implementation of this strategy should be experimental and adaptive to test efficacy of approach.

2. Collaborate with Wildlife Services, guides, ranchers and the land management agencies where depredations of livestock by mountain lions and black bears occur to increase additional hunting and guiding opportunity under the current depredation law A.R.S. § 17-302 and associated Commission Rule A.A.C. R12-4-305(H).

3. When appropriate, use current hunt structures (limit, population management hunts, and multiple bag limits) to increase the harvest of mountain lions and bears in areas of high livestock depredation caused by mountain lion and black bear.

4. Work with livestock producers and land management agencies to employ innovative livestock and husbandry practices that reduce the risk of depredation, such as the avoidance of calving operations within mountain lion habitat.

SUPPORTING INFORMATION

Descriptions of current genetic and geospatial planning approaches are provided for perspective in using these conservation strategies.

GENETICS

The use of genetic analysis techniques in bear and mountain lion conservation and management has great potential to support and direct management decisions and is beginning to provide insights unavailable by any other methods. The variety of topics that can be addressed through the application of genetic methodologies ranges from relatedness of known individual animals to species-wide assessments. Genetic analysis allows gathering of information relevant to mountain lion and bear conservation and management, with respect to evolution, taxonomy, and population characteristics, such as inbreeding, dispersal or migration rates, and population size. Incorporating such information into management decisions can be a critical tool for maintaining functioning sustainable populations with natural levels of gene flow.

Genetic information is of increasing importance in the conservation and management of wild populations for several reasons. First, the rapid development of new genetic techniques continually increase the usefulness of sources containing little or degraded DNA from samples collected non-intrusively (e.g., hair and feces), greatly facilitating the study of elusive species like carnivores. Second, new types of genetic markers and equipment have dramatically improved the level of resolution and the quantity of genetic data that can be efficiently extracted. Third, the interpretation of genetic data is constantly improved by the development of new statistical methods and models. All this makes genetic applications well suited to address a wide range of questions in natural populations.

Molecular markers can be used to describe subdivisions (or taxonomy) within a species, which can be more reliable than taxonomy based on morphology alone. This technique alone reduced the morphological classification of mountain lions from 32 subspecies to 6 (Culver et al. 2000), eliminating the Yuma Puma designation and justified management actions that introduced introgression of mountain lions into the Florida panther population. DNA molecules can also be used to examine population boundaries, population size, or evidence of migration-dispersal among populations, by assessing levels of gene flow among populations. In addition, genetic studies can be used to explain behavioral differences due to gene variation or to relatedness-kinship among individuals. Genetic techniques have been used as a forensic tool to estimate population features for unknown populations or to aid in wildlife law enforcement. Finally, genetics of a virus infecting populations can be an effective tool to estimate ecological parameters for those populations.

A wide variety of genetic markers can be used for wildlife applications including mitochondrial DNA, nuclear DNA genes, DNA fingerprinting, microsatellite DNA, Y-chromosome DNA, and DNA from viruses infecting the study species. Some genetic techniques are designed to analyze a single region, or locus, of DNA (RFLP, DNA sequencing), whereas other techniques examine many loci at the same time (DNA fingerprinting). Polymerase chain reaction is a technological advance in molecular genetics that allows easy, quick, and inexpensive amplification of a specific region of DNA across many individuals. This technique makes it possible to analyze samples with poor quality and/or very low quantity of DNA (such as museum, forensic, hair, or scat samples). Each of the markers is characterized by distinct rates of evolution and thereby possesses different levels of resolution to analyze distant or recent divergences. The assumption that the distribution of genetic variation in natural populations should reflect the influences of historical, geographical, and ecological factors is what makes these markers useful in mountain lion and bear conservation and management.

The need to understand how genes are distributed within and among populations led to the development of population genetics. Population genetic models can be used to quantify and predict genetic structure (population subdivision) and gene flow at the population level. It is also possible to calculate the effective population size (Ne), a metric of huge importance for population genetic processes. It is defined as the size of an ideal population that would loose genetic variance (by genetic drift) at the same rate as the population under study (Wright 1931). Ne reflects the number of animals in a population whose genes are actually transmitted to the next generation, directly affecting a process called genetic drift (the random fluctuation of allele frequencies in a population over time). Genetic drift eliminates, or fixes, alleles proportional to Ne. Thus, a larger Ne has a smaller chance of losing allelic variants and, conversely, alleles have a greater chance of elimination in small populations. As allelic variation is lost, adaptive potential is eroded.

Dispersal, considered to have evolved as a mechanism to avoid inbreeding, has wide-ranging effects at virtually every level, from species to the individual. For example, at the population level it affects species distribution and abundance, social structure, and gene flow. At the individual level it affects survival and reproductive success. No biological process is unaffected by dispersal. But, despite this fundamental importance of dispersal, our understanding is lacking because dispersal is difficult to estimate. Direct observations of dispersal are restricted by the logistical difficulty to track dispersers or radiotag sufficient numbers to monitor populations.

Early efforts to look at genetic relatedness between individuals were limited by low genetic resolution. More recently, the relatedness between two individuals can be inferred from their degree of pairwise band sharing from genetic data compared to the population average.

An individual's genotype can be used as a unique tag for repeated sampling (similar to capture-mark-recapture). Such genetic monitoring, where individuals or populations are sampled repeatedly over time, can be used to quantify many basic individual and population metrics (e.g. effective population size, reproductive success, dispersal). It is typically more effective, more accurate and cheaper than traditional methods (Schwartz et al. 2007).

DATA MANAGEMENT NEEDS

The Department currently has five separate databases that capture information about bears and mountain lions. Each database was originally developed to capture specific information regarding these species (sport harvest, depredation kills, road kills, marked animals, or human-wildlife encounters). These databases were created using different software packages which makes querying them difficult at best and impossible to query simultaneously. The hunter harvest and depredation kill databases have been converted from dBase to Informix (our main frame system) where all other species harvest data resides. The road kills, marked animals, and human-wildlife encounters databases were merged into an MS Access database then converted to an SQL database. The SQL conversion is still in progress and has numerous troubleshooting concerns.

Ideally, these databases would all be linked, relational databases with set queries and reports for retrieving and reporting data from all five areas simultaneously. The databases would not necessarily have to be linked but would need some similar fields that would allow for this "canned" query. The databases should also be web-enabled with a geo-referencing and mapping component for both data entry (plotting the location event) and reports. Incorporating geo-referencing in the databases would provide a visualization component to our dataset and aid in management decisions. According to Department personnel involved with Geographic Information Systems (GIS) and mapping, a rough cost estimate for developing such a database (without a formal Request for Information) is $250,000 minimum.

An ideal component for data capture would allow field personnel the ability to enter the data at the time of the event. ESRI (a vendor on contract) offers a product called ArcPad that operates on hand-held devices such as PDAs and Blackberries. Using software such as ArcPad increases the accuracy and efficiency of data collection and expands access to geo-spatial data in the field. Electronically capturing data while in the field improves the quality and accuracy of the data, while reducing administrative and data entry time. Satellite coverage is necessary for this system to work. The current cost per ArcPad software license is $515.00. Ideally, every wildlife manager would have access to this technology (80 x $515 = $41,200). All field data including, but not limited to, carcass checks, radiotelemetry data, road kill locations, depredation reports, sightings and human conflict reports could be delivered and accessed by such a program and would facilitate the management of data needed to manage large carnivores.

GEOSPATIAL PLANNING

The Areas of Conservation Priority (ACP) created by the Arizona Game and Fish Department is a raster-based GIS platform developed to model wildlife resources for the state of Arizona. The current version of the ACP model has two main components: biological value and threats (stressors) to wildlife. Its application to mountain lion and black bear management has not yet been directed by the Commission or Department policy.

An opportunity exists in the development of future geospatial concepts using GIS platforms to include mapping distribution and estimated abundance of mountain lions and bears. In addition, estimated hunters, hunter days, and economic contributions to the Department and the local community could be included in a manner that would allow planners to evaluate estimated impacts on populations of wildlife and revenue streams.

RESEARCH NEEDS

Management of mountain lions and black bears faces challenges in the coming decade. Challenges involve conservation and maintenance of populations in relation to increasing human-mountain lion encounters, increasing depredations of domestic pets and livestock, mortality on ungulate prey, and changing prey bases. Resource managers must face these challenges with a relatively sparse databank of information to guide them, and nowhere is this deficit more critical than in Arizona. Biologists have learned much about mountain lion and black bear ecology in the past 40 years or so, but most of the research contributing to this knowledge has resulted from studies conducted in habitats dissimilar to Arizona's. To some extent, these studies have provided knowledge to guide mountain lion and black bear management in Arizona, but ecology of the predators varies among arid, semi-arid, and more mesic regions. We suggest that a need has emerged for increased mountain lion and black bear management efforts supported by research in Arizona's diverse habitats, and for reassessment of management goals to consider landscape scale variables such as habitat fragmentation and vegetation changes resulting from fires, and an immediate need for population genetics information to determine population sizes. Additional research needs to target the influence of shifting prey population abundance and dynamics on mountain lion and bear abundance. Habitat fragmentation merits additional attention.

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