

# Cougars



*Past, Present and Future Challenges*

**9th MOUNTAIN LION WORKSHOP**

**Proceedings**

**Hosted by Idaho Department of Fish and Game**

**Sun Valley, Idaho**

**May 5 - 8, 2008**

*Proceedings of  
The 9<sup>th</sup> Mountain Lion Workshop  
Cougars: Past, Present and Future Challenges*



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**Sanctioned by**  
Western Association of Fish and Wildlife Agencies

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## **IN REMEMBRANCE**

There are giants who have contributed greatly to our understanding of cougars and our professional development. We are fortunate to still have them in our presence. There are others who contributed significantly to cougar research, management, and conservation and who were well on their way to becoming such giants. We lost them all too soon. They remind us of the risks taken to explore, research, and understand wildlife and natural areas. It is appropriate at this 40<sup>th</sup> anniversary of the beginning of cougar research in Idaho that we recognize and remember the contributions of these friends and colleagues whom we deeply miss.

**Knut Atkinson 1957 – 1996**  
**Steve Laing ???? – 1991**  
**Orval Pall 1951 – 1986**  
**Greg Felzien 1965 – 1991**  
**Michael Gratson 1952 – 2000**  
**Ian Ross 1958 – 2003**  
**Rocky Spencer 1952 – 2007**  
**Eric York 1970 – 2007**  
**David Maehr 1955 – 2008**  
**Ted McKinney 1937 - 2008**

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## Distinguished Service Awards Maurice Hornocker Wilbur Wiles

Two pioneers in cougar research were presented with achievement awards at the 9th Mountain Lion Workshop in Sun Valley Idaho, May 5-8th 2008.

**Dr. Maurice Hornocker** was presented with a Lifetime Achievement Award on behalf of the cougar research community, including Mountain Lion Workshop participants, Hornocker Institute employees, the University of Idaho Taylor Ranch Field Station, the Idaho Department of Fish & Game, the DeVlieg Foundation, and several of Hornocker's University of Idaho graduate students.

Dr. Hornocker served as leader of the Idaho Cooperative Wildlife Research Unit for 17 years. He also founded two research institutes: the Hornocker Wildlife Institute and the Selway Institute. Dr. Hornocker's research findings were instrumental in transferring the status of mountain lions in Idaho from bounty animal to a respected big game species. Dr. Hornocker conducted the first major mountain lion research project, starting in 1968 in Big Creek, Idaho.

Dr. Hornocker credits a great deal of his research success to his houndsman and research assistant, **Wilbur Wiles**. Wiles worked with Hornocker and graduate students from 1964 through 1973. Although Wiles was unable to attend the workshop, he was acknowledged during the workshop banquet and later given the Idaho Conservation Award in a small ceremony at his home in Big Creek, Idaho on July 15<sup>th</sup>, 2008.

Hornocker and Wiles received unique cougar prints by artist Tom Mansanarez to commemorate their contributions to our understanding of mountain lion ecology.



(L-R): Kerry Murphy, Gary Koehler, Jim Akenson, Holly Akenson, Mike Tewes, Toni Ruth, Maurice Hornocker, Howard Quigley, and Steve Nadeau (IDFG) at the 9<sup>th</sup> Mountain Lion Workshop, Sun Valley, May 7<sup>th</sup>, 2008.



(L-R): Toni Ruth, Leslie Hornocker, Maurice Hornocker, Wilbur Wiles, Jim Akenson, Holly Akenson. Presented to Wilbur Wiles at Big Creek on July 15<sup>th</sup>, 2008.

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# Preface

## *Chronology of Mountain Lion Workshops*

- 1<sup>st</sup> Mountain Lion Workshop – Sparks, Nevada, 1976
- 2<sup>nd</sup> Mountain Lion Workshop – St. George, Utah, 1984
- 3<sup>rd</sup> Mountain Lion Workshop – Prescott, Arizona, 1988
- 4<sup>th</sup> Mountain Lion Workshop – Denver, Colorado, 1991
- 5<sup>th</sup> Mountain Lion Workshop – San Diego, California, 1996
- 6<sup>th</sup> Mountain Lion Workshop – San Antonio, Texas, 2000
- 7<sup>th</sup> Mountain Lion Workshop – Jackson Hole, Wyoming, 2003
- 8<sup>th</sup> Mountain Lion Workshop – Leavenworth, Washington, 2005
- 9<sup>th</sup> Mountain Lion Workshop – Sun Valley, Idaho, 2008

The 9<sup>th</sup> Mountain Lion Workshop was held in Sun Valley, Idaho from May 5-9, 2008. The theme for the workshop was *Past, Present, and Future Challenges*. Organizers provided sessions for state and province status reports; interactions with humans and the urban interface; habitat use and movements; multi-carnivore and prey interactions; genetics and disease; population estimation and dynamics; education and social issues; and key concepts. During the state status reports, the state managers were asked to provide the 2 primary issues their jurisdiction is dealing with in regards to cougar management. On the last day of the workshop, a panel of experts discussed these issues and opened the discussion to workshop participants. A poster session was also provided with many excellent posters from students and researchers. The banquet night was also a 40<sup>th</sup> anniversary celebration of cougar research by Dr. Maurice Hornocker and Wilbur Wiles in central Idaho, and we provided them both with lifetime achievement awards.

There were 165 registered participants. We received \$34,902.81 in registration fees, contributions, sponsorships and vendor fees. We expended \$33,067.48, which left us with \$1,835.33 which will mostly go toward printing of the proceedings, the remainder will be sent to WAFWA. We provided each conference registrant with several conference items along with an abstract/agenda book for the price of the registration. Sun Valley is an expensive place to hold a conference, but due to vendors and sponsors, we were able to hold registration fees to \$175. Thanks again to sponsors - The DeVlieg Foundation, The Cougar Fund, and the Felidae Conservation Fund. The rooms and facilities were top notch, banquet food was excellent, and I only heard praise about the facilities. We had two field trips, a bird watching expedition and a wolf viewing and management tour.

Cougar management though different in each state does have overarching similarities. Management of problem cougars was a common theme in every state, particularly at the urban interface. Most states provide a protocol for dealing with problem cougars. Also of interest was the similarity in cougar population growth during the 1980's and peaking in the mid late 1990's, then a decline during the last decade. This trend was found in almost every state including California where they do not allow hunting. Funding, long-term research, and population estimation were all concerns. On Thursday afternoon of the conference, WAFWA cougar

guidelines team members met to review the status of writing, review concepts, and discuss direction with writers and chapter leaders.

The next state to host the workshop will be Montana. Rich DeSimone and Jim Williams from Montana Fish Wildlife and Parks will be co-chairing. The time and location have not yet been set, but it will be in 2011, likely May or June in northwestern Montana, possibly Whitefish area. The Conference schedule is now every 3 years so that the black bear and mountain lion conferences would not occur on the same year.

Thank you all for attending and contributing to a truly great workshop! See you in Montana.

Steve Nadeau  
Committee Chairman  
9<sup>th</sup> Mountain Lion Workshop

**9<sup>th</sup> Mtn. Lion Workshop Agenda**  
**Cougar Management and Research: Past, Present, and Future Challenges**

**May 5<sup>th</sup> through 9<sup>th</sup>**

**Monday May 5<sup>th</sup> – Registration 3-6, 6pm Social**

**Tuesday May 6<sup>th</sup> –**

8:00-8:30

Welcome – Conference Chairman, **Steve Nadeau** (Large Carnivore Manager, IDFG)

Welcome Address – **Virgil Moore** (Deputy Director, IDFG)

Invited speaker- **Mike Tewes** (Texas A&M University-Kingsville and Caesar Kleberg Wildlife Research Institute)

State and Province Status Reports

**Session Chair: Steve Nadeau**

8:30-8:45 Idaho *Steve Nadeau*

8:45-9:00 Washington *Rich Beausoleil*

9:00-9:15 Oregon *Don Whittaker*

9:15-9:30 California *Doug Updike*

9:30-9:45 Montana *Jim Williams*

9:45-10:00 Wyoming *Daniel Thompson*

10:00-10:15 Morning Break

10:15-10:30 Texas *John Young*

10:30-10:45 Nevada *Kevin Lansford*

10:45-11:00 Utah *Kevin Bunnell*

11:00-11:15 Colorado *Jerry Apker*

11:15-11:30 New Mexico *Darrell Weybright*

11:30-11:45 Arizona *Ron Thompson*

11:45-12:00 South Dakota *John Kanta*

Lunch 12:00-13:00

Paper Presentations: **Interactions with Humans at the Urban Interface**

**Session Chair: Terry Mansfield**

13:00-13:20 Distribution and movements of mountain lions associated with human residential/urbanized areas in north-central Arizona. *Ted McKinney and Scott Poppenberger*

13:20-13:40 Demographic and landscape influences on cougar-human interaction in western Washington. *Brian Kertson, Rocky Spencer, and Christian Grue*

13:40-14:00 Cougar spatial and habitat use in relation to human development in central Washington. *Benjamin Maletzke, Gary Koehler, and Robert Wielgus*

14:00-14:20 Challenges and opportunities facing Florida panther conservation – can we increase the size of the box? *Darrell Land and Chris Belden*

14:20-14:40 Puma movements relative to housing density in southern California. *Christopher Burdett, Kevin Crooks, David Theobald, Ken Wilson, and Walter Boyce*

14:40-15:00 Prospects for mountain lion persistence in a complex urban landscape in southern California. *Seth Riley, Jeff Sikich, Eric York, and Raymond Sauvajot*

Break 15:00-15:15

Paper Presentations: **Habitat Use and Movements**

**Session Chair: Dorothy Feske**

15:15-15:35 Novel spatial tools for connectivity conservation: A case study using cougars in southern California. *Rick Hopkins, Brett Dickson, and Brad McRae*

15:35-15:55 Daily movement distances of Florida panthers assessed with GPS collars. *Marc Criffield, Dave Onorato, Mark Cunningham, Darrell Land, and Mark Lotz*

15:55-16:15 Potential habitat and dispersal corridors for cougars in the Midwest. *Clayton Neilsen and Michelle LaRue*

16:15-16:35 Refining the use of GPS telemetry cluster techniques to estimate cougar kill rate and prey composition. *Kyle Knopff, Aliah Knopff, and Mark Boyce*

16:35-16:55 Does rural development fragment puma habitat? *Anne Orlando, Steve Torres, Walter Boyce, Evan Girvetz, Emilio Laca, and Montague Demment*

17:30-19:00 **Poster Session with poster presenters present for discussion**

**Wednesday May 7<sup>th</sup> –**

Paper Presentations: **Multi-carnivore and Prey Interactions**

**Session Chair: Howard Quigley**

08:00-08:20 Cougar reproduction and survival pre- and post-wolf reintroduction in Yellowstone National Park. *Toni Ruth, Polly Buotte, Mark Haroldson, Kerry Murphy, Maurice Hornocker, and Howard Quigley*

08:20-08:40 Foraging ecology of jaguars in the southern Pantanal, Brazil: kill rates, predation patterns, and species killed. *Eric Gese and Sandra Cavalcanti*

08:40-09:00 Cougar home range shifts and apparent decrease in cougar abundance in the southern greater Yellowstone ecosystem. *Drew Reed, Travis Bartnick, Marilyn Cuthill, Dan McCarthy, Howard Quigley, and Derek Craighead*

09:00-09:20 Wolf and bear detection of cougar-killed ungulates on the Northern Range of Yellowstone National Park. *Polly Buotte, Toni Ruth, and Maurice Hornocker*

09:20-09:40 Cougar scavenging behavior and susceptibility to snaring at bait stations. *Aliah Knopff, Kyle Knopff, and Mark Boyce*

09:40-10:00 Lion movement patterns in Grand Canyon National Park. *Eric York and Rolla Ward*

Morning Break 10:00-10:15

Paper Presentations: **Genetics and Disease**

**Session Chair: Rich DeSimone**

10:15-10:35 Using DNA to estimate cougar populations: a collaborative approach.

*Richard Beausoleil, Kenneth Warheit, Wan-Ying Chang, Donald Martorello, and John Pierce*

10:35-10:55 Estimating lion population abundance using DNA samples in the Blackfoot drainage of west-central Montana. *Richard DeSimone, Michael Schwartz, Kristine Pilgrim, and Kevin McKelvey*

10:55-11:15 Estimation of the bottleneck size in Florida panthers. *Melanie Culver and Philip Hedrick*

11:15-11:35 Evaluation of noninvasive genetic sampling methods for cougars using a radiocollared population in Yellowstone National Park. *Michael Sawaya, Toni Ruth, and Steve Kalinowski*

11:35-11:55 A preliminary retrospective on the implementation of genetic introgression in the Florida panther. *Dave Onorato, Warren Johnson, Melody Roelke, Mark Cunningham, Darrell Land, Mark Lotz, Roy McBride, David Shindle, Deborah Jansen, Oron Bass, and Stephen O'Brien*

Lunch 12:00-13:00

#### Paper Presentations: **Population Estimation and Dynamics**

##### **Session Chair: Bruce Ackerman**

13:00-13:20 Evaluation of cougar population estimators in Utah. *David Choate, Michael Wolfe, and David Stoner*

13:20-13:40 Dynamics and demography of a central Washington cougar population. *Hillary Cooley, Gary Koehler, Benjamin Maletzke, and Robert Wielgus*

13:40-14:00 Variation in cougar survival by individual traits, density, and seasonal weather. *Diana Ghikas, Matin Jalkotzy, and Ian Ross*

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14:20-14:40 Source-sink dynamics and the recovery of overexploited cougar populations. *David Stoner and Michael Wolfe*

14:40-15:00 Censusing pumas by categorizing physical evidence. *Roy McBride, Rocky McBride, Rowdy McBride, and Cougar McBride*

Afternoon Break 15:00-15:15

#### Paper Presentations: **Education and Social Issues**

##### **Session Chair: Gary Koehler**

15:15-15:35 Studying public perceptions and knowledge of cougars in Washington as a precursor to outreach and education planning. *Chris Morgan, Jim Harmon, and Donald Martorello*

15:35-15:55 The Land of the Living Dead comes alive: The Florida panther in Big Cypress. *Deborah Jansen and Roy McBride*

15:55-16:15 Project CAT (Cougars and Teaching) ... What the community has learned. *Trish Griswold, Spencer Osbolt, Sarah Gronostalski, Jamie French, Benjamin Wagsholm, Kevin White, Gary Koehler, and Benjamin Maletzke*

16:15-16:35 Science and education working together to promote lion awareness at Grand Canyon. *Lori Rome*

16:35-16:55 A new paradigm for partnerships in cougar research and management. *Laura Foreman*

18:00-22:00 Banquet in Limelight Salon B  
Guest Speaker: Maurice Hornocker

### **Thursday May 8<sup>th</sup>** –

08:00-10:00 Panel on **Mt. Lion Challenges of Past, Present, and Future**

**Session Chair: Jim Akenson**

Panel Members: Howard Quigley, Terry Mansfield, Gary Power, Gary Koehler,  
Steve Nadeau, Linda Sweanor

10:00-10:15 Morning Break

Paper Presentations: **Key Concepts**

**Session Chair: Kerry Murphy**

10:15-10:35 Implications of sink populations in large carnivore management: cougar demography and immigration in a hunted population. *Hugh Robinson, Robert Wielgus, Hillary Cooley, and Skye Cooley*

10:35-10:55 Dispersal movements of subadult cougars from the Black Hills of South Dakota and Wyoming: concepts of range edge, range expansion, and repatriation. *Daniel Thompson, Jonathan Jenks, and Brian Jansen*

10:55-11:15 Formation of a professional organization: the Wild Felid Research and Management Association. *Linda Sweanor, John Beecham, Chris Belden, Deanna Dawn, Richard DeSimone, Gary Koehler, Sharon Negri, Chris Papouchis, Hugh Robinson, and Ron Thompson*

11:15-11:35 Cougar management protocols: a survey of wildlife agencies in North America. *Richard Beausoleil, Deanna Dawn, Chris Morgan, and Donald Martorello*

11:35-11:55 **Cougar Management Guidelines (First and Second Edition)**

Presenter: *Russ Mason* (WAFWA guidelines chairman)

11:55-12:00 Logistics and closing remarks *Steve Nadeau*

12:00-13:00 Lunch

13:00-13:30 Business meeting WAFWA state/province representatives, vote for next conference location.

13:30-16:00 Afternoon meeting with Cougar Management Guidelines authors, past and present  
Afternoon/evening field trip Birding/Waterfowl at Camas Prairie Wildlife Management Area

### **Friday May 9<sup>th</sup>** –

Wolf Field Trip – Meet at front lobby at 07:00 hrs. Load in buses and drive with wolf biologists to Sawtooth National Recreation Area wolf rendezvous sites, discuss wolf management, biology, delisting, wolf viewing, monitoring, etc.. Wolf biologists will be scouring the area for wolves prior to the field trip. Return to resort around noon.

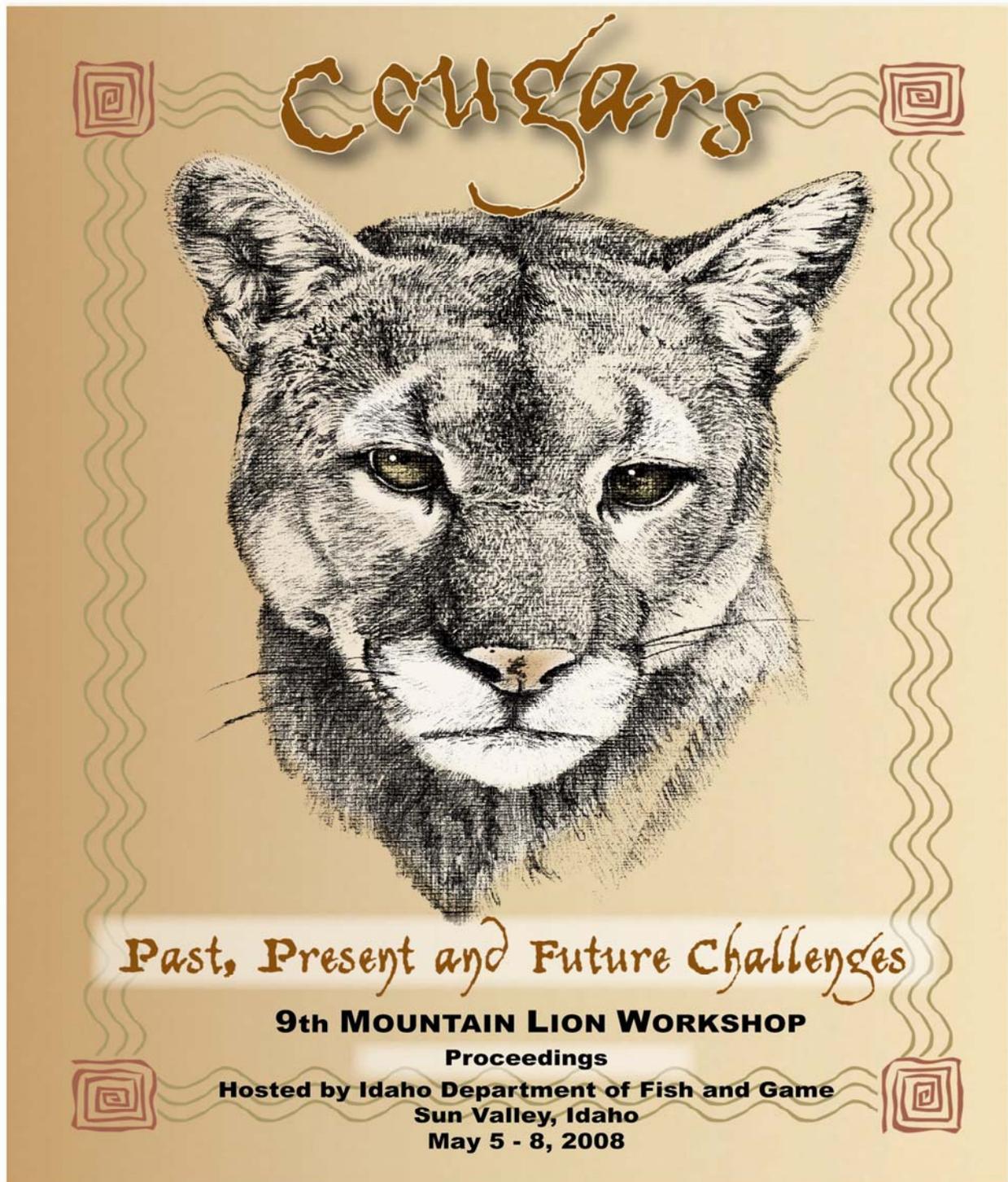
**Posters –Posted the entire conference, but presented Tuesday 1730-1900hrs**

- Ecology of a re-established cougar population in southeastern Alberta and southwestern Saskatchewan. *Michelle Bacon and Mark Boyce*
- Generating an index of relative abundance for cougars throughout the Jackson Hole, Wyoming, area using winter tracking methods. *Travis Bartnick, Dan McCarthy, Marilyn Cuthill, Drew Reed, Howard Quigley, and Derek Craighead*

- Movements of a female cougar on the human-wildlands interface. *Marilyn Cuthill, Dan McCarthy, Travis Bartnick, Drew Reed, Howard Quigley, and Derek Craighead*
- Estimating cougar abundance in northeastern Oregon. *Scott Findholt and Bruce Johnson*
- Survival and ages of cougars harvested after cougar hunting with dogs was banned in Oregon. *Scott Findholt, Bruce Johnson, DeWaine Jackson, James Akenson, and Mark Henjum*
- Research and educational efforts by the Cougar Network. *Clayton Neilsen, Mark Dowling, Kenneth Miller, Robert Wilson, Harley Shaw, Charles Anderson, and Scott Wilson*
- Intra-specific variation in cougar behavior in the southern Greater Yellowstone Ecosystem. *Dan McCarthy, Marilyn Cuthill, Travis Bartnick, Drew Reed, Howard Quigley, and Derek Craighead*
- Mountain lion movements relative to development, roads, and trails in a fragmented landscape. *Jeff Sikich, Seth Riley, Eric York, and Raymond Sauvajot*
- Cougars in British Columbia: conservation assessment and science-based management recommendations. *Corinna Wainwright and Chris Darimont*
- Safety and effectiveness of cage traps for the capture of cougar. *Brian Kertson, Rocky Spencer, and Bruce Richards*
- Cougar-induced vigilance in ungulate prey: does predator proximity matter? *David Choate, Gary Belovsky, and Michael Wolfe.*
- Variations in the reproductive success of female cougars by individual traits, density, and seasonal weather. *Diana Ghikas, Martin Jalkotzy, and P. Ian Ross.*



# State and Province Mountain Lion Status Reports



## Idaho Mountain Lion Status Report

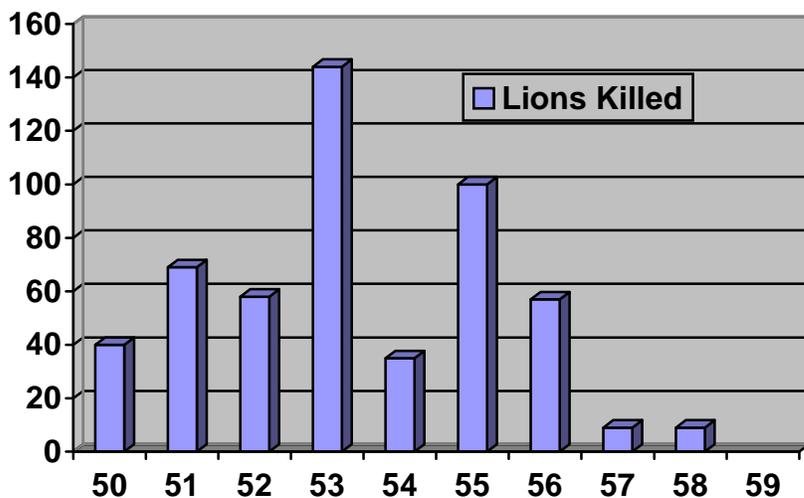
Steve Nadeau, Large Carnivore Manager, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83709, USA. [snadeau@idfg.idaho.gov](mailto:snadeau@idfg.idaho.gov)

**ABSTRACT** Lions were classified as big game animals in 1972. The 1990 Mountain Lion Management Plan, called for the reduction in harvest of female lions, and to maintain a harvest of approximately 250 lions statewide. However, lion harvest peaked statewide in 1998 when 798 lions were harvested. Consequently, a new lion plan was developed to address the increases in the populations and allow more hunting opportunity. Idaho completed the latest Mountain Lion Management Plan in 2002. The lion plan called for maintaining current lion distribution statewide as a goal and to not allow harvest and populations to drop below the 2002 levels. However, individual regions could adjust harvest to either increase or decrease populations depending upon the objectives for that area. Seasons were made more lenient, running from 30 August to 31 March in most units, and until 30 June in two desert canyon units. In some areas, two-lion bag limits were initiated. Hounds were allowed in most units, and non-resident hound hunting was expanded. Female quotas were used in most of the southern part of the state until recent population expansions, and by 2008, quotas remain in only 20 of 99 units.

### History

The legal status and public perception of mountain lions in Idaho has changed over time. In the late 1800s and early 1900s, mountain lions and other predators such as wolves, coyotes, grizzly and black bears were perceived as significant threats to livestock and human interests and were systematically destroyed. Between 1915 and 1941, hunters employed cooperatively by the State, livestock associations, and the Federal Government killed 251 mountain lions in Idaho; the take by private individuals is not known. During the period 1945-1958, bounties were paid for mountain lions in Idaho with an annual average of 80 mountain lions turned in for payment (Fig. 1). The 1953-54 winter periods yielded the highest recorded bounty harvest of 144 mountain lions (Fig. 1). Bounty payments ranged from \$50 in the early 1950's to \$25 per lion during the last 4 years of payments.

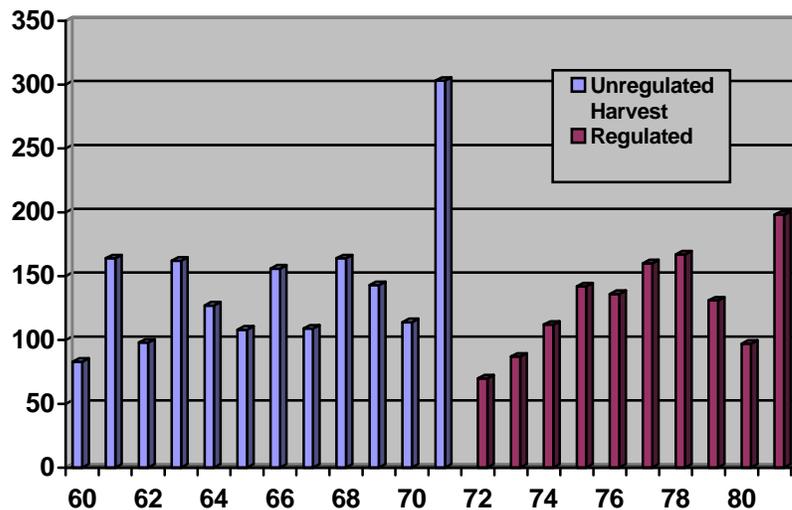
### Mountain Lion Bounty Mortality Records



**Figure 1.** Mountain lion bounty records, 1950 – 1959. From 1950-1954, the bounty was \$50 per lion; from 1955-1959, the bounty was \$25 per lion.

Mountain lion sport harvest became increasingly popular after 1958. Average annual harvest was estimated at 142 lions from 1960 through 1971 (Fig. 2). During this period there were no restrictions or regulations on the harvest of mountain lions. An estimated 303 lions were harvested during the 1971-72 season.

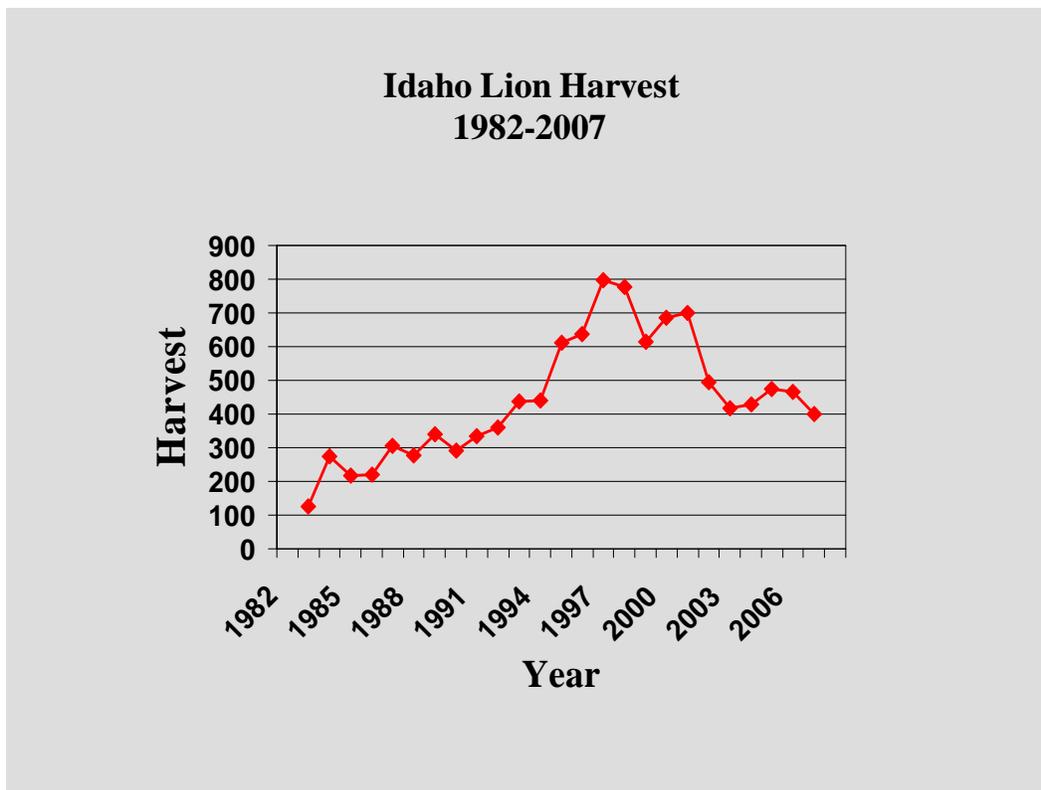
### Mountain Lion Sport Harvest



**Figure 2.** Unregulated mountain lion harvest from 1960-71, and regulated harvest from 1972 - 1981.

Research conducted by Maurice Hornocker in the Frank Church River of No-Return Wilderness from 1964-1973 added significantly to our knowledge. As a result of this research, the mountain lion was reclassified as a big game animal in 1972. Harvest was then able to be regulated and resulted in some closed units, bag limits, and shortened seasons. Mandatory reporting was started in 1973, and a tag has been required since 1975.

Populations of elk and deer continued to increase across the state during the 1980s and early 1990s, and the resulting mountain lion population increased as well. The apparent increase in lion populations allowed the department to increase opportunity for harvest. Harvest continued to increase as a result of liberalized seasons and increased populations and peaked in 1997 (Fig. 3). However, harvest has declined since the peak and has recently stabilized at about 450 lions per year since 2003. Harvest declined despite liberalized seasons, suggesting a lower population level than during the peak.



**Figure 3.** Statewide mountain lion harvest from 1982-2007.

### **Distribution and Abundance**

Lions were distributed across most of the suitable habitat in the state. Management tended to keep lion populations at a low density in developed areas or areas with high road density. However, most of the areas that received high harvest lay adjacent to lightly roaded reservoir areas that seemed to continue to provide dispersing animals. Distribution appeared to be

somewhat stable, though overall abundance apparently declined. Mountain lion harvest was reported in most counties across Idaho. As deer and elk winter range get developed, residential areas now interface with wildlife habitat. Some conflicts with lions result.

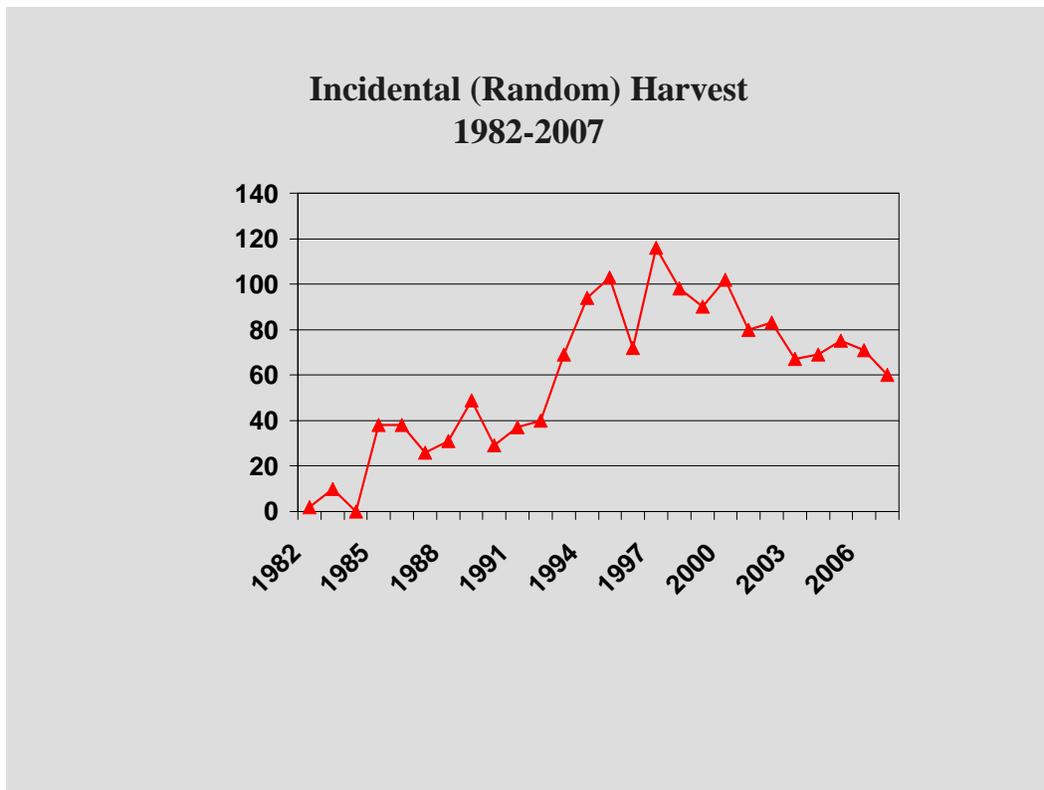
Population estimates have not been made for Idaho in recent years, though some radio collaring mortality information in Idaho indicated a high rate of sustainable harvest in some areas. Given an estimated harvest rate statewide of approximately 15-20% (estimated to stabilize the population), we would back calculate and estimate a state population of about 2,000-3,000 lions. Research was attempted to develop a population index; however, nothing was finalized (Zager et al. 2002). All lions legally harvested must be reported. Pelts were tagged and a premolar was removed for aging. Prior to 2000, lion ages were estimated using tooth drop measurements. Based on various tests, tooth sectioning replaced tooth drop as a more reliable estimate of age and has been used statewide since 2002. For data analysis purposes, units were grouped by similar characteristics into Data Analysis Units (DAUs). Age data and harvest rates were used to attempt to identify population trends for a lion population by DAU. Population models using these harvest data were used to estimate population demographics and relative abundance.

### **Harvest Information**

Lion harvest increased steadily through the 1980s and 1990s and peaked at 798 mountain lions harvested in 1997. Lion harvest declined in most areas of the state following the 1997 season, despite a liberalized lion hunting season in most of the state, but has recently stabilized (Fig. 3).

There were 99 big game management units in Idaho, which were grouped into 18 mountain lion management DAUs. Until 2003, the southern part of the state was predominantly managed under a female quota system, and the northern part of the state was mostly general hunts with most seasons running from 30 August to 31 March. Quotas and seasons were set by unit or DAU, usually based on historical harvest rates, big game objectives, depredations, perceived lion population condition, lion hunter success rates and perceptions, public input, and commission desires. Over the last few years, general seasons replaced quotas in 33 units, so that since 2005, only 22 units still had female quotas. Many of the quotas were removed in areas where the quotas were seldom reached, or in areas where deer or elk population objectives were not being met. Quotas are popular among most hound hunters.

Incidental harvest may be another indicator of population changes through time if tag types, hunters, and seasons are held steady. Incidental harvest by hunters in search of other big game would typically be considered a product of a random encounter. Random encounters increase as populations of lions or hunters increase. Incidental harvest in north Idaho general hunts peaked during the mid to late 1990's. The incidental harvest in southern Idaho quota hunts peaked a few years later. Overall incidental harvest peaked during 1998, the same period that total harvest peaked (Fig. 3, 4).

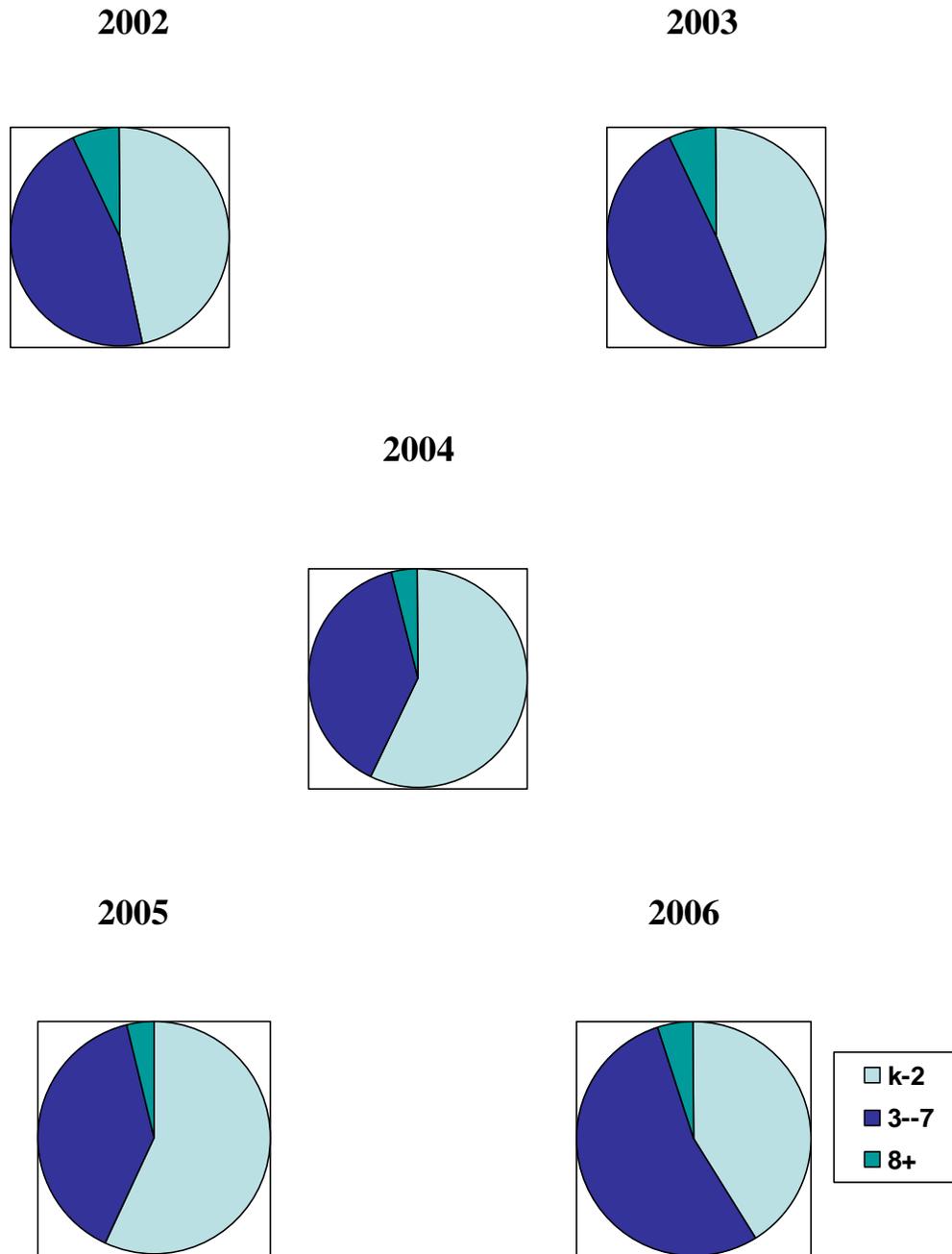


**Figure 4.** Incidental mountain lion harvest in Idaho from 1982 – 2007 more closely represents random encounters with lions and thus is a more representative depiction of mountain lion populations.

Biological objectives for lions were not well established by DAU. Tooth removal for age data was attempted on all lions harvested. Harvest levels reflected in proportions of sex and age were described in Anderson (2003.) This technique was used to monitor and adaptively manage populations by attempting to grow or reduce populations through harvest management, and monitor resultant age/sex structure shifts in the harvest. Regional wildlife managers in the state were given a great deal of flexibility to be able to set objectives for a given DAU.

Age data were analyzed to compare population demographics between and among years since 2002 (Fig. 5). Even at the statewide level, age proportions did not seem to represent significant changes between years that would represent significant trends.

## Idaho Cougar Ages



**Figure 5.** Statewide age structure comparisons of lion harvest in Idaho from 2002-2007. Ages were grouped as kitten through 2 years, 3-7 years, and  $\geq 8$  years.

Hunting with hounds accounted for about 80% of the annual lion harvest in Idaho. The rest of the harvest occurred incidentally to other big game hunting (13%), spot and stalk (5%), or predator calling (1%). The use of electronic calls was allowed in two management units where predation was a concern and access was limited. Dogs were prohibited through much of the general deer and elk rifle seasons. Pursuit with dogs was allowed in units with female quotas once the quota was reached. In a few of these units, hunting for males was allowed once the female quota was reached.

Mountain lion tag sales increased 8% from 2004 – 2007, and in 2007 were at an all-time high of 23,357 total tags sold (Table 1). Reduced prices, increased nonresident sales of special tags, and liberalized seasons and nonresident hound hunter regulations all added to increased sales. Additionally, in some parts of the state, outfitters were engaged to increase harvest of lions to help reduce predation problems on elk and bighorn sheep. Also, nonresidents can use their deer tag to kill a black bear or mountain lion. Nearly 3,000 hound permits were issued to residents and >100 to nonresident hound hunters each of the last several years.

**Table 1.** Mountain lion tag sales in Idaho from 1998 through 2006.

Year	Resident Tags	Nonresident Tags	Total Tags Sold
1998	16,196	351	16,547
1999	17,072	813	17,885
2000	18,369	961	19,330
2001	18,561	888	19,449
2002	19,757	883	20,640
2003	19,832	725	20,557
2004	20,875	768	21,643
2005	21,784	699	22,483
2006	22,416	786	23,202
2007	22,596	761	23,357

### Depredations and Human Conflicts

Currently, Idaho law allows for killing lions or black bears that are in the act of “molesting” or attacking livestock. Lions killed in this fashion need to be reported to the Department. Idaho law also allows lions that are perceived as threats to human safety to be killed. Department policy provides that lions that have caused problems or have depredated should be captured and euthanized. Most depredations are reported to U.S. Wildlife Services and they handle the removal. Policy also provides that lions that present a threat due to proximity to residential housing or other area of human habituation or activity should be moved or chased in a preemptive fashion. Depending on the circumstance, if the animal has become habituated or caused problems, the lion can be destroyed. Orphaned kittens are not rehabilitated for release back into the wild.

Idaho averaged 3-4 safety-related complaints annually from 1998-2004 and about 50% required capture or removal of a lion. There has been 1 recorded human injury in Idaho caused by lions,

and that occurred in 1999 to a 13-year-old boy. However, close encounters and even stalking behavior are regularly recorded but seldom tolerated. Some lions live in or near populous areas, and will kill domestic animals as well as urban wildlife. Once problems arise, lions are usually destroyed. Transplanting of habituated or food-conditioned lions is not conducted.

Lion-related depredations that required compensation averaged about 1-2 per year. Average annual compensation from 1998-2002 was \$4,717 for lion depredations on livestock. During that same time, 46 lions were removed due to depredation situations.

## **Research**

The Department researched techniques for population monitoring in north-central Idaho by conducting aerial track surveys (Gratson and Zager 2000), and a mark-recapture technique using rub stations and biopsy darts (Zager et al. 2004). These efforts have not yet been finalized.

## **Literature Cited**

- Anderson, C. R., Jr. 2003. Cougar ecology, management, and population genetics in Wyoming. Dissertation, University of Wyoming, Laramie, USA.
- Gratson, M. W., and P. Zager. 2000. Elk ecology. Study IV. Factors influencing elk calf recruitment. Job No. 2. Calf mortality causes and rates. Federal Aid in Wildlife Restoration, Job Progress Report, W-160-R-26. Idaho Department of Fish and Game, Boise, USA.
- Zager, P., and C. White. 2004. Elk ecology: Study IV. Factors influencing elk calf recruitment. Federal Aid in Wildlife Restoration, Job Progress Report, Project W-160-R-31. Idaho Department of Fish and Game, Boise, USA.

## Washington Mountain Lion Status Report

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Donald A. Martorello, Bear, Cougar, and Special Species Section Manager, Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501, USA.

**ABSTRACT** This status report focuses on cougar management developments since the 8th Mountain Lion Workshop. Readers interested in regulations, seasons, harvest statistics, or status and trend reports can obtain that information online by visiting Washington Department of Fish and Wildlife's internet website at:

[http://www.wdfw.wa.gov/hunting/game\\_species/bear\\_cougar/index.html](http://www.wdfw.wa.gov/hunting/game_species/bear_cougar/index.html)

### Cougar Legislation

Engrossed Substitute House Bill 2438 (HB 2438), was signed by the 60<sup>th</sup> Washington State Legislature in the 2008 Regular Session. The Bill passed 66 to 29 in the House of Representatives, 31 to 18 in the Senate, and the Governor signed it on 13 March, 2008. It will become effective on 12 June 2008. This Bill instructs Washington Department of Fish and Wildlife (WDFW) and commissioners from 5 northeast counties (Chelan, Okanogan, Ferry, Stevens, and Pend Oreille) to continue with a pilot program that authorized a cougar pursuit season and a cougar kill season with the aid of dogs for 3 additional years. Essentially, HB 2438 is a continuation of 2 previous bills, Substitute Senate Bill 6118 (SSB 6118), which created this cougar pilot program in 2004, and Engrossed Substitute House Bill 1756 (HB 1756), which extended it for 1 year in 2007. When first presented this year, HB 2438 was a modified version of SSB 6118, amended most notably to allow statewide participation in the program, and making the use of dogs permanent in Washington, thus overturning Initiative 655 (I655) approved by voters in 1996. When it appeared that HB 2438 was beginning to stall in the House, amendments were made that modified the language from a permanent program to a 3-year extension; at that point it moved forward. Along with the continuation of the pilot program in the 5 counties, HB 2438 allows the 34 remaining counties in Washington the ability to opt in to this program. To opt in, the language in HB 2438 states: *“A county legislative authority may request inclusion in the additional 3 years of the cougar control pilot project authorized by section 1 of this act after taking the following actions: (1) Adopting a resolution that requests inclusion in the pilot project; (2) Documenting the need to participate in the pilot project by identifying the number of cougar/human encounters and livestock and pet depredations; (3) Developing and agreeing to the implementation of an education program designed to disseminate to landowners and other citizens information about predator exclusion techniques and devices and other non-lethal methods of cougar management; and (4) Demonstrating that existing cougar depredation permits, public safety cougar hunts, or other existing wildlife management tools have not been sufficient to deal with cougar incidents in the county.”* Finally, it is stated that the pilot program's primary goals are *“to provide for public safety, to protect property, and to assess cougar populations.”* A second Bill, Senate Bill 6918 (SB 6918), was also introduced in 2008 that would have designated the cougar as the official state mammal but it died in committee after the first reading. Anyone interested in reading this Bill in its entirety, or

the approximately 15 other bills involving cougar since 1996, can visit the Washington State Legislature homepage at <http://www.apps.leg.wa.gov/billinfo/>

## **Cougar Management Plan**

The Department is in the process of updating the Game Management Plan for all game species including cougar. As of May 2008, WDFW was soliciting input on the draft supplemental environmental impact statement (SEIS), which included updates to the current plan developed in 2003. Public comments on the draft will be used to prepare a final SEIS and the Washington Fish and Wildlife Commission will review that document in August 2008. Once finalized and approved, WDFW will incorporate changes into the 2009-2015 Game Management Plan. In the cougar section, along with public input, WDFW personnel are analyzing research and management findings in preparation for a busy wildlife commission cycle. The challenge is to use these findings to incorporate new strategies and priorities into cougar management and address all aspects of management including quotas, bag limits, season dates, season structure, permit draw hunts, pursuit seasons, public education, and hunter education requirements.

## **Cougar Mortality Data Collection**

We recently revisited our data collection protocols as they relate to cougar mortalities in Washington. With the establishment of statewide DNA collection from all cougar mortalities several years ago, ongoing tooth collection for aging cougars via cementum annuli, and big game mortality forms that field personnel used to collect data (all via a mandatory sealing requirement), we decided to standardize our data collection methods. We created a cougar mortality envelope that incorporates all these techniques, eases the burden on field-staff time, and insures a timely transfer of information. On one side, the envelope is self-addressed, labeled with handling instructions, and pre-paid for postage; on the other side is a modified datasheet. When a cougar mortality occurs, field staff from around the state fill in the pertinent data, collect a premolar tooth and a tissue sample (depositing the tissue in a supplied vial that is pre-filled with ethanol and individually labeled inside and out), deposit the samples inside the envelope, then seal the envelope and mail it. The envelope is delivered to a central location where the data are recorded electronically and the samples are prepared for lab analysis.

## **Cougar Research Cougar DNA Project – Northeast Washington**

For 5 consecutive years, WDFW has been conducting a cougar DNA project to estimate cougar abundance in northeast Washington. The objectives of this project were to: (1) Acquire a scientific population estimate of cougars in northeast Washington; (2) Test the efficacy and practicality of using DNA capture techniques to estimate cougar population size; and (3) Manage project costs to allow agencies interested in the technique to potentially conduct the research for decades. We used a capture-recovery methodology. Instead of using conventional markers (i.e., radiocollars, eartags, and tattoos), we used DNA from tissue samples collected from treed cougar as our “capture” and DNA samples collected from harvested cougar as our “recovery.” Tissue from both sample sessions was analyzed using microsatellite analysis. The DNA fingerprint analysis consisted of positively identifying 24-36 alleles (12-18 loci) for each tissue sample.

Samples that did not produce a minimum of 12 loci were censored. We extracted the specified number of loci from 128 of 163 cougar samples resulting in identification of 100 individual cougars in the “capture” sessions. Preliminary results of this project were presented at this workshop and will ultimately be submitted for publication.

### **Cougar Population and Survival Project – North Central Washington (NCW)**

Since 2004, WDFW has been monitoring cougar populations in Okanogan County, the largest county in Washington State. Objectives of the project are to acquire demographic parameters from cougar populations in NCW (with an emphasis on female and cub survival and population size), provide a current scientific estimate of cougar density in NCW, use science to meet WDFW management goals and objectives for effective management to provide WDFW with population and survival estimates for NCW, the essential data necessary to modify existing regulations, guidelines, and quotas in NCW. To date, 36 cougars (21F, 15M) have been captured, 34 were collared (19F, 15M) and 14 mortalities (9F, 5M) have been documented. Of the 19 known cougar kittens, 12 have survived (63%). Results are currently being analyzed for publication.

### **Project C.A.T. – Central Washington**

Project C.A.T. (Cougars and Teaching), the cooperative research and education program between WDFW and the Cle Elum-Roslyn School District, is nearing the end of an 8-year landmark cougar project. The scientific objectives were to investigate changes in cougar travel patterns, habitat use, and predation events as residential and recreational development increased in a rural community. The education objectives were to provide K-12 students with an experiential curriculum which focused on the local environment and the changes occurring, allowing middle and high school students to participate in captures of cougars and marking them with GPS collars. Project personnel captured and marked 46 cougars (31 male and 15 female) from kittens to adults. More than 28,000 GPS locations were obtained from 26 adult and sub-adult cougars (10 females, 16 males). All collars deployed in winter 2007-08 have been up fitted with timed breakaway functions to drop off the animals in winter 2009. The project will continue through community outreach and experiential education; however, personnel will focus efforts on data analysis rather than field research on cougars.

### **WDFW / Washington State University – Northeast Washington**

In 2006, Catherine Lambert published her M.S. research findings, "Cougar population dynamics and viability in the Pacific Northwest," in the *Journal of Wildlife Management*. Hugh Robinson completed his dissertation titled "Cougar Demographics and Resource Use in Response to Mule Deer and White-tailed Deer Densities," in May 2007. The first publication from his research will be published in an upcoming issue of *Ecological Applications*. A second manuscript on cougar habitat use and prey abundance will be submitted for publication in summer 2008. Hilary Cooley published results from her M.S. research in *Journal of Wildlife Management* in January 2008. She is currently a Ph.D. candidate studying the effects of hunting on cougar population dynamics and demography. Her expected completion date is August 2008. Benjamin Maletzke, a Ph.D. candidate, began his cougar research in winter 2006. He is part of the ongoing research

for Project CAT; his primary focus is cougar age structure and social organization in relation to human development. His expected completion date is Fall 2009. Jon Keehner is a M.S. candidate studying prey selection of cougars and how it differs demographically; his expected date of completion is December 2008. He plans to continue the project for a Ph.D. examining the role of sexual segregation of cougars by elevation and its role in prey selection. Kevin White, a M.S. candidate involved in ongoing research for Project CAT, is studying cougar prey use and habitat characteristics associated with predation sites within a mule deer/elk prey system. His expected completion date is December 2008.

### **WDFW / University of Washington – Western Washington**

University of Washington M.S. student Brian Kertson completed his research in fall of 2006. His research, titled “Cougars and Citizen Science,” evaluated the ability of over two hundred 3rd, 5th, and 8th grade student volunteers to collect scientifically credible data on wildlife and their habitats within the context of Project CAT. Results of the evaluation were mixed, but this research suggests with adequate training and study design students working as citizen scientists can make valuable contributions to cougar research and management projects. A manuscript of this research is nearing completion and should be submitted for publication in the coming months. Phase Two of Project CAT research, examining the role of landscape features and population demographics on cougar-human interaction in western Washington, was initiated in the winter of 2006 and is being conducted by Brian as part of his Ph.D. program with the Washington Cooperative Fish and Wildlife Research Unit. Currently, research activity is focused on data collection with 32 cougars (adult and subadult) that have been captured to date. The anticipated completion of fieldwork and dissemination of research findings is Fall 2010.

### **Cougar Education**

In Spring 2008, WDFW and Insight Wildlife Management conducted a public opinion survey. The objective of the survey was to better understand the public’s perceptions of cougar management, identify information gaps, and define effective outreach methodologies. The survey included questions about the ecological role of cougars, cougar behavior, human-cougar conflict, availability of educational materials, and preferred themes for education programs. Using a random sampling telephone survey method, we obtained results from over 800 individuals and conducted a stratified sub-sample in areas with a higher than average frequency of human-cougar conflicts. Survey results will be compared to data from similar surveys in other states. Ultimately, the survey will be used to develop a public outreach and education plan about cougar ecology, behavior, safety, and management in Washington. Results of this survey were presented at this workshop.

Along with cougar education WDFW provides to the public via the Department website, the use of brochures, periodic press releases, and public presentations, another effective way to reach the public is cooperative partnership with local land trust organizations. The Chelan-Douglas Land Trust in central Washington recently released *The Chelan County Good Neighbor Handbook: Tools for Living in Chelan County Washington*. Department personnel provided input on this document and the focus is on educating people about land stewardship. The handbook is a guide for current and new residents that may not be aware of the responsibilities/challenges that come

with moving to a semi-rural mountainous area. Too often, real estate agencies advertise the scenic beauty of these places, touting the mountains, rivers, rolling meadows, wildflowers, and sometimes even deer and elk, without also mentioning that predators make their home in these places. Educating existing and incoming homeowners to be stewards and work to prevent conflict will be a monumental challenge.

**THIS ENVELOPE FOR BEAR & COUGAR ONLY**

Officer / Biologist: \_\_\_\_\_ Date of Seal: \_\_\_\_\_

Hunter Name (Last, First): \_\_\_\_\_ Wild ID #: \_\_\_\_\_

Species: Bear \_\_\_ Cougar \_\_\_ Date of Kill (month/day/year): \_\_\_ / \_\_\_ / \_\_\_ Seal # \_\_\_\_\_

Dogs used? Yes No Weapon Type: Modern Firearm \_\_\_ Archery \_\_\_ Muzzleloader \_\_\_ Sex of Kill: Male \_\_\_ Female \_\_\_

If female, was she lactating? Yes No GMU of Kill: \_\_\_\_\_ County of Kill \_\_\_\_\_

Age Class of Kill (see age guide): Cub / kitten \_\_\_ Sub-Adult \_\_\_ Adult \_\_\_

Location of Kill: (please be specific) \_\_\_\_\_

Kill Type: General Hunt \_\_\_ Special Permit Hunt \_\_\_ Depredation \_\_\_  
 Landowner Kill \_\_\_ Poached \_\_\_ Roadkill \_\_\_

Body Condition Score (See guide): \_\_\_\_\_ Gun Recession measurements (only for cougar) (L&R): \_\_\_\_\_

Premolar tooth collected? Yes No Tissue Sample Collected? Yes No Vial Number: \_\_\_\_\_

Did the animal have an ear tag (or a hole in the ear)? Yes No Tag number: \_\_\_\_\_ Tag Color: \_\_\_\_\_

Did the animal have a radiocollar (or "wear" marks)? Yes No Frequency: \_\_\_\_\_

Graphic shows the location of the first premolar tooth to collect for bear & cougar reporting

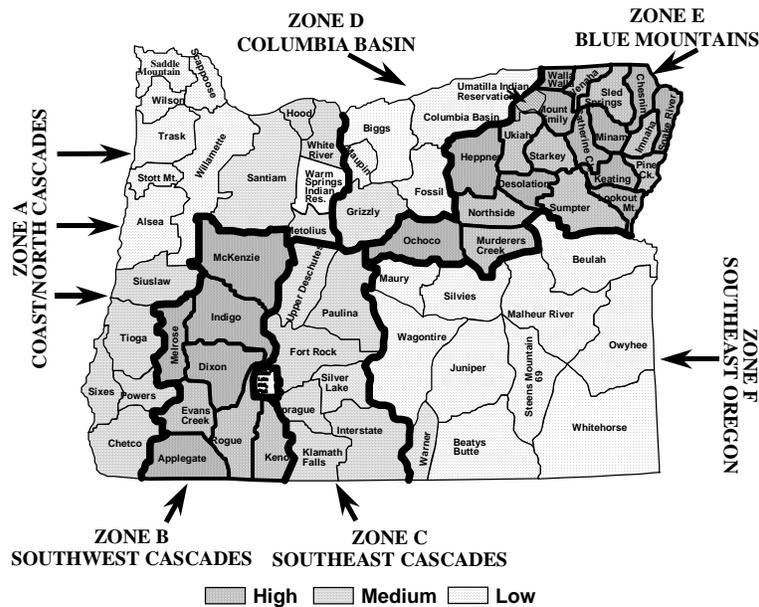


**Figure 1. Mortality envelope currently being used in Washington to collect data on bear and cougar mortalities state-wide. Along with pertinent data, tissue (in pre-labelled vials) and tooth samples are also collected and deposited into the envelope.**

# Oregon Mountain Lion Status Report

Donald G. Whittaker, Species Coordinator, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue NE, Salem, OR 97303, USA [donald.whittaker@state.or.us](mailto:donald.whittaker@state.or.us)

Cougar (*Puma concolor*) occur at varying densities across the majority of the Oregon landscape (Fig. 1). Persecuted to near extirpation by the mid 1960s, the then Oregon State Game Commission was given management authority by the 1967 Oregon Legislature. Oregon’s first Cougar Management Plan was developed in 1987 with revisions in 1993, 1998, and 2006. The most recent 2006 revision established 5 guiding objectives for cougar management in Oregon:



**Figure 1.** Current distribution and relative density of cougar in Oregon by Big Game Management Unit and Harvest Quota Zone.

- 1) Oregon Department of Fish and Wildlife (ODFW) will manage for a cougar population that is at or above the 1994 level of approximately 3,000 cougars statewide.
- 2) ODFW will proactively manage cougar-human conflicts as measured by non-hunting mortalities and ODFW may take management actions to reduce the cougar population.
- 3) ODFW will proactively manage cougar-human safety/pet conflicts as measured by human safety/pet complaints and ODFW may take management action to reduce the cougar population.
- 4) ODFW will proactively manage cougar-livestock conflicts as measured by non-hunting mortalities and livestock damage complaints and ODFW may take management actions to reduce the cougar population.
- 5) ODFW will proactively manage cougar populations in a manner compatible and consistent with management objectives for other game mammals outlined in ODFW management plans.

Within these objectives, a number of zone-specific criteria are established that trigger management actions and are used to monitor progress toward objectives (Table 1). Proactive management of cougars may include intensive, administrative removal of cougars in targeted areas where zone specific criteria have been met.

Importantly, the plan also established an Adaptive Management process for plan implementation. Within an adaptive framework, management actions will be planned to address 1 of 4 hypotheses and evaluated by monitoring specific criteria:

**Table 1.** Specific management criteria associated with the 2006 Oregon Cougar Management Plan Objectives

Zone	Population $\hat{N}$		Non-Hunt Mortality		Human/Pet Conflicts		Livestock Conflicts	
	Desired $\hat{N}_{min}$	Modeled $\hat{N}_{2007}$	Desired Max	2007 Observed	Desired Max	2007 Observed	Desired Max	2007 Observed
A Coast/ N Cascades	400	805	15	46	191	33	102	70
B Southwest Cascades	1,200	1,499	11	51	84	54	69	60
C Southeast Cascades	120	556	5	5	28	14	24	8
D Columbia Basin	80	352	5	28	20	3	12	11
E Blue Mountains	900	1,605	13	71	22	16	25	8
F Southeast Oregon	300	849	11	26	54	5	27	6
Statewide Total	3,000	5,666	60	227	399	125	259	163

- 1) Increased cougar mortality near human habitation will reduce cougar-human conflicts to desired levels. Criteria to measure conflict will primarily be non-hunting mortality and secondarily number of complaints received.
- 2) Increased cougar mortality in areas with low ungulate population levels will increase ungulate recruitment or survival and allow population objectives to be met. Criteria to measure elk recruitment will be based on spring calf:cow ratios. Trend counts or population modeling will determine attainment of ungulate population objectives.
- 3) Areas with low – medium cougar harvest will act as source populations to maintain cougar populations at or above minimum levels. Criteria to measure cougar population status will be based on known cougar mortality (total mortality, age and sex ratios, average age of adult females), research results, and population modeling.
- 4) Increased cougar mortality near areas of livestock concentrations will reduce cougar-livestock conflicts to desired levels. Criteria to measure conflict will primarily be non-hunting mortality and secondarily the number of complaints received.

Management actions will be implemented, and monitoring will be conducted within the established cougar management zone framework in Oregon. Total mortality is monitored using quotas delineated based on landscape characteristics, prey populations, and relative density (Fig. 1).

### Hunting Seasons and Harvest Trends

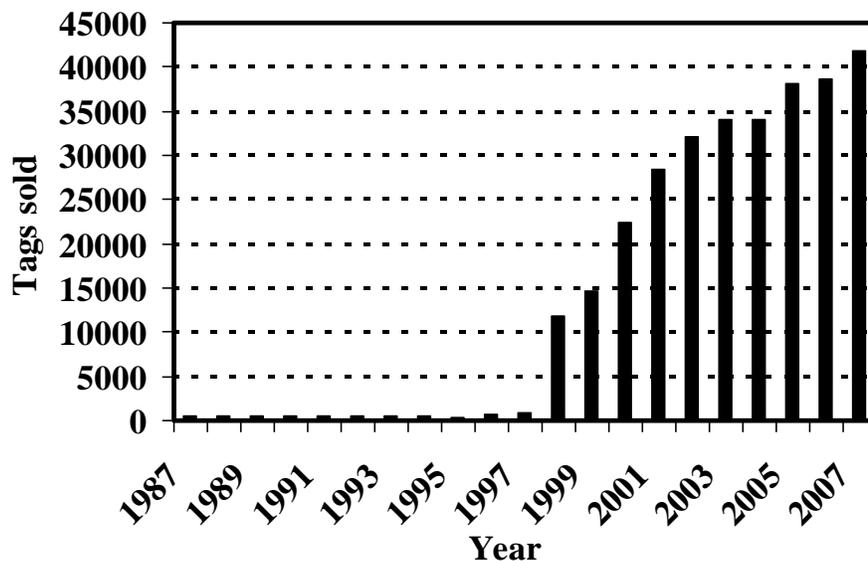
Cougar hunting in Oregon has evolved from no regulation, through complete protection and tightly controlled limited hunting, to a liberal general season. Currently, statewide general

cougar seasons are 10 months long (1 Jan – 31 May, and 1 Aug – 31 Dec annually), year-round general season hunting is allowed in southwestern Oregon to help reduce high conflict levels, and use of hounds is allowed only by agency personnel when addressing specific conflict or management needs. A mandatory check-in is required for all known cougar mortalities. Harvest and total mortality are managed using quotas by Management Zone (Fig. 1, Table 2).

**Table 2.** Harvest/mortality quotas for cougar management zones in Oregon, 2000 – 2007.

Quota Zone	2000	2001	2002	2003	2004	2005	2006	2007
A Coast/N Casc.	91	91	93	116	128	132	120	120
B SW Cascades	104	104	106	133	146	150	165	165
C SE Cascades	36	36	37	46	51	53	65	65
D Col. Basin	13	13	13	16	18	19	62	62
E Blue Mtns.	96	96	98	123	135	139	245	245
F SE Oregon	60	60	61	76	84	87	120	120
Totals	400	400	408	510	562	580	777	777

Quotas were revised in 2006 concurrent with revision of the Cougar Management Plan and all known mortalities count toward quotas as a protective measure for cougar populations. Total number of hunters with cougar tags continues to increase (Fig. 2). This increase is related to a reduction in the cougar tag price, inclusion of a cougar tag in a reduced price multiple-tag package available to resident hunters. A second tag has been available statewide since 2006. Concurrent with increasing cougar hunter numbers, overall hunter success rates have dropped from 40-50% when hounds were legal to  $\leq 1\%$ . However, hunter harvest has continued to slowly increase to levels greater than when hounds were legal for hunting (Table 3). Between 85 – 96% of the cougar harvest occurs incidental to hunting other species such as deer and elk. From 48 – 62% of the harvest are males.



**Figure 2.** Cougar tag sales trend in Oregon. 1987 – 2007.

**Table 3.** Cougar mortalities in Oregon by source of mortality, 1987 – 2007.

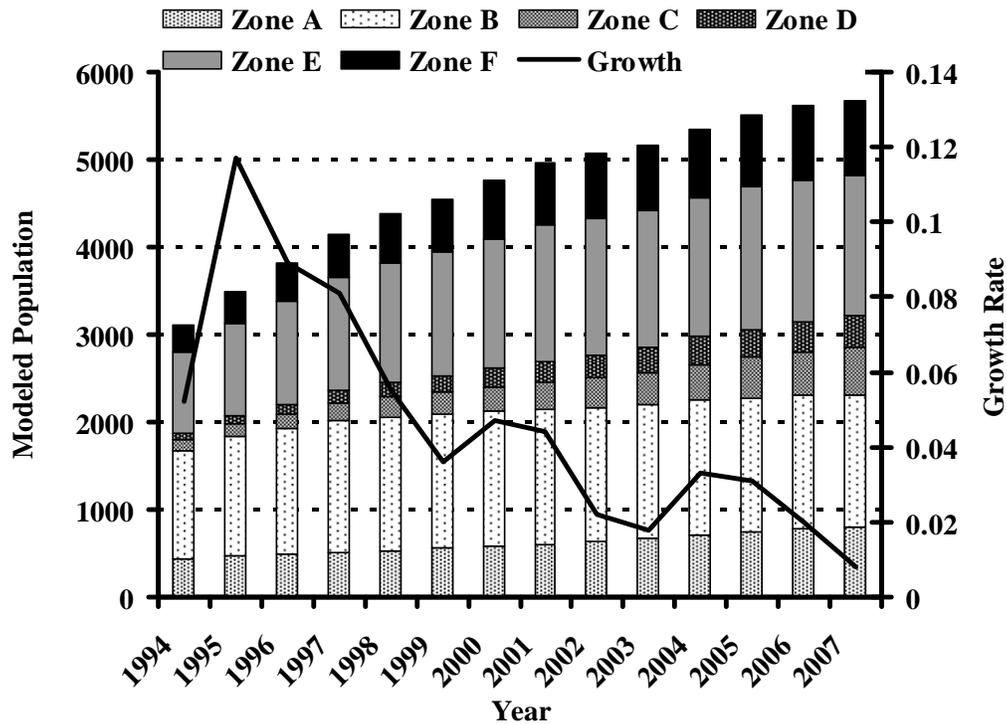
Year	Hunting	Human/Pet Safety	Livestock Conflict	Administrative Removal	Other	Total
1987	129	2	8	0	3	142
1988	136	3	13	0	10	162
1989	116	1	15	0	13	145
1990	201	3	29	0	18	251
1991	124	4	22	0	12	162
1992	184	3	17	0	22	226
1993	162	7	20	0	21	210
1994	199	11	29	0	20	259
1995	22	22	41	0	12	97
1996	43	34	64	0	25	166
1997	61	20	82	0	18	181
1998	110	20	93	0	17	240
1999	169	39	91	0	25	324
2000	188	27	120	0	17	352
2001	220	27	98	0	21	366
2002	232	25	111	0	35	403
2003	248	28	110	0	25	411
2004	265	28	95	0	35	423
2005	224	28	125	0	30	407
2006	289	26	105	0	32	452
2007	308	21	113	52	41	535

<sup>a</sup> Proactive administrative removal in selected targeted areas began in 2007.

price, inclusion of a cougar tag in a reduced price multiple-tag package available to resident hunters. A second tag has been available statewide since 2006. Concurrent with increasing cougar hunter numbers, overall hunter success rates have dropped from 40-50% when hounds were legal to  $\leq 1\%$ . However, hunter harvest has continued to slowly increase to levels greater than when hounds were legal for hunting (Table 3). Between 85 – 96% of the cougar harvest occurs incidental to hunting other species such as deer and elk. From 48 – 62% of the harvest is males.

## Population Status and Trend

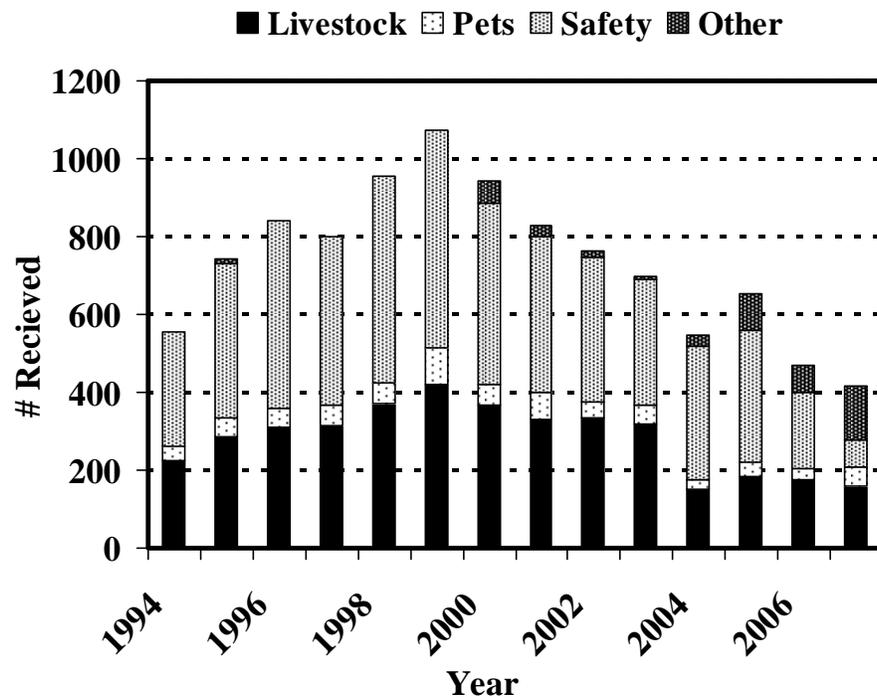
Status of cougar populations in Oregon is monitored using a deterministic computer model (Keister and Van Dyke 2002) adapted to represent population changes at the regional level, characteristics of the harvest, and trends in non-hunting mortalities. Modeled population trend continues to increase (Fig. 3). However, as total mortality has increased (Table 3), and populations approach assumed density dependence limits in the model, growth rate in the modeled population has declined and is approaching zero (Fig. 3).



**Figure 3.** Modeled (Keister and Van Dyke) cougar population growth in Oregon, 1994–2007.

## Conflict

Number of cougar related conflicts is declining in Oregon (Fig. 4). Human safety concerns and livestock complaints are the dominant form of incident reported. Number of cougars killed as a result of conflict with humans also has increased with most cougars killed in response to conflict with livestock (Table 3). Because of recent changes in recording protocols in Oregon, the number of incidents reported as just a cougar sighting is no longer monitored.



**Figure 4.** Trend in incidents of human-cougar conflict for Oregon, 1994–2007.

## Management Conclusions

In general, the Department feels cougar populations recovered from the extremely low levels in the 1960s and are distributed throughout the state of Oregon. The Department recently revised its Cougar Management Plan. Direction established by the revised plan focuses primarily on reducing and managing conflict within an adaptive management approach where we can learn from actively addressing issues.

## California Mountain Lion Status Report

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### Distribution and Abundance

Lions are currently distributed throughout all suitable habitats within California. Lion numbers appear to be stable at an estimated 4,000 to 6,000 adults.

The number of lions in California is based upon extrapolating densities determined with the use of radio collars. These studies have been conducted in various locations of the state. The number of lions is determined by multiplying the densities and the area represented by the ecological province. The studies which provide local lion density data have been conducted over a period of a couple decades. Consequently, the Department recognizes the estimate has limited application.

The Department issues depredation permits to property owners who have experienced damage from a mountain lion. The following graph represents the number of mountain lion depredation permits issued and the number of lions which have been killed as a result.

### Human Interactions/Conflicts

The Department's Public Safety Guidelines are included. This policy is intended to guide the actions and decisions of Department personnel who respond to mountain lion incidents.

A summary of the number of human/lion incidents (2000-2007) is provided below:

	<u>2000</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>
# of incidents	372	456	379	419	715	556	464	392
# of safety incidents	8	14	13	3	12	10	16	21
# Lions taken	7	11	13	2	12	7	11	12
male	4	8	6	1	6	1	3	6
female	3	3	5	1	5	5	6	5
unknown	0	0	2	0	1	1	2	1
# of sightings	174	240	224	237	503	423	351	291

We provide educational material to the public to foster an understanding and appreciation of lions. Most of the information, including our brochure, "Living with California Mountain Lions", is available at <http://www.dfg.ca.gov/news/issues/lion.html>.

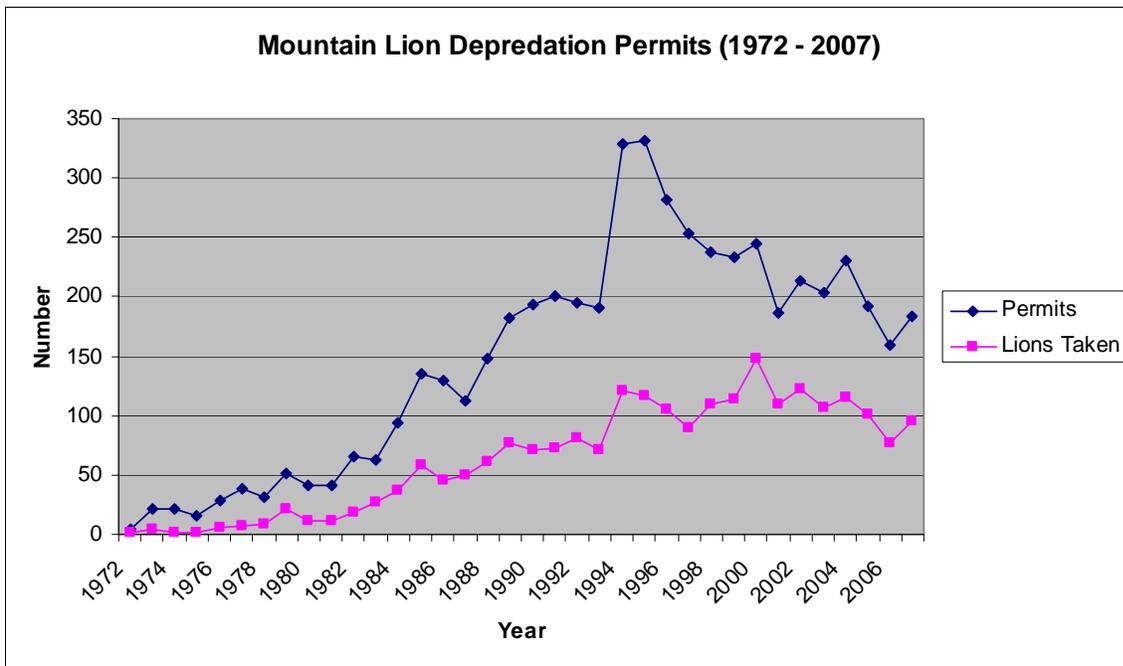
The Department has completed a multiple species program to reduce interactions between wildlife and humans. This is the "Keep Me Wild" program, and the specific recommendations for mountain lions are available at <http://www.keepmewild.org/whattodolion.htm>.

Depredation permits may be issued by the Department subject to the conditions found in Section 402, California Code of Regulations, as follows:

- (a) Revocable permits may be issued by the department after receiving a report, from any owner or tenant or agent for them, of property being damaged or destroyed by mountain lion. The department shall conduct and complete an investigation within 48 hours of receiving such a report. Any mountain lion that is encountered in the act of inflicting injury to, molesting or killing livestock or domestic animals may be taken immediately if the taking is reported within 72 hours to the department and the carcass is made available to the department. Whenever immediate action will assist in the pursuit of the particular mountain lion believed to be responsible for damage to livestock or domestic animals, the department may orally authorize the pursuit and take of a mountain lion. The department shall investigate such incidents and, upon a finding that the requirements of this regulation have been met, issue a free permit for depredation purposes, and carcass tag to the person taking such mountain lion.
- (b) Permittee may take mountain lion in the manner specified in the permit, except that no mountain lion shall be taken by means of poison, leg-hold or metal-jawed traps and snares.
- (c) Both males and females may be taken during the period of the permit irrespective of hours or seasons.
- (d) The privilege granted in the permit may not be transferred, and only entitles the permittee or the employee or agent of the permittee to take mountain lion. Such person must be 21 years of age or over and eligible to purchase a California hunting license.
- (e) Any person issued a permit pursuant to this section shall report by telephone within 24 hours the capturing, injuring or killing of any mountain lion to an office of the Department or, if telephoning is not practical, in writing within five days after capturing, injuring or killing of the mountain lion. Any mountain lion killed under the permit must be tagged with the special tag furnished with the permit; both tags must be completely filled out and the duplicate mailed to the Department of Fish and Game, Sacramento, within 5 days after taking any mountain lion.
- (f) The entire carcass shall be transported within 5 days to a location agreed upon between the issuing officer and the permittee, but in no case will a permittee be required to deliver a carcass beyond the limits of his property unless he is willing to do so. The carcasses of mountain lions taken pursuant to this regulation shall become the property of the state.
- (g) Animals shall be taken in a humane manner so as to prevent any undue suffering to the animals.
- (h) The permittee shall take every reasonable precaution to prevent the carcass from spoiling until disposed of in the manner agreed upon under subsection (f) of these regulations.

- (i) The permit does not invalidate any city, county or state firearm regulation.
- (j) Permits shall be issued for a period of 10 days. Permits may be renewed only after a finding by the department that further damage has occurred or will occur unless such permits are renewed. The permittee may not begin pursuit of a lion more than one mile nor continue pursuit beyond a 10-mile radius from the location of the reported damage.

The number of depredation permits has increased dramatically since the early 1970s; the number peaked in 1995, the year following two fatal attacks on humans. The number of permits issued and the number of lions taken as a result of those permits is shown below (Fig 5):



**Figure 5.** The number of permits issued and the number of lions taken as a result of those permits

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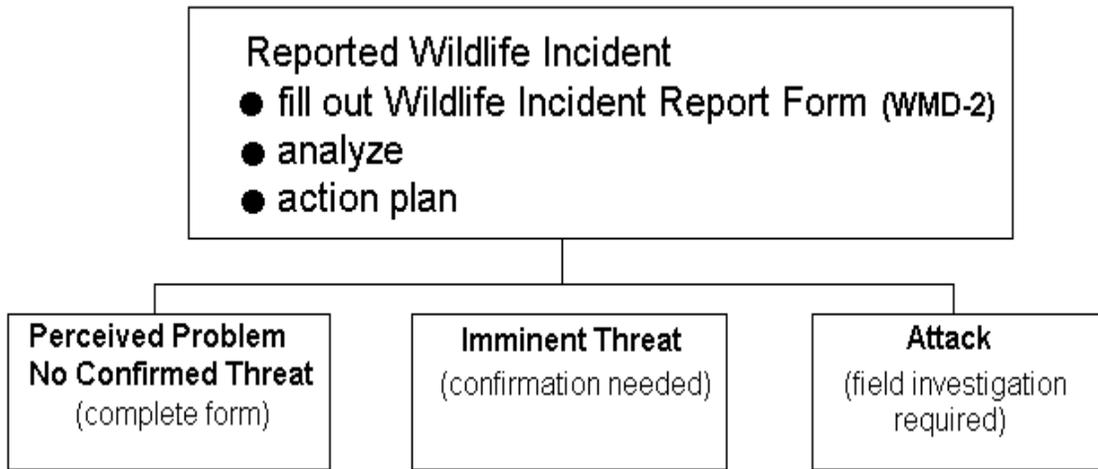
Consistent with Section 1801 of the Fish and Game Code, these Public Safety Wildlife Guidelines provide procedures to address public safety wildlife problems. Mountain lions, black bears, deer, coyotes, and large exotic carnivores which have threatened or attacked humans are wildlife classified as public safety problems. Public safety wildlife incidents are classified into three types:

- A. Type Green (sighting): A report (confirmed or unconfirmed) of an observation that is perceived to be a public safety wildlife problem. The mere presence of the wildlife species does not in itself constitute a threat.
- B. Type Yellow (threat): A report where the presence of the public safety wildlife is confirmed by a field investigation and the responding person (law enforcement officer or Department employee) perceives the animal to be an imminent threat to public health or safety. Imminent threat means there is a likelihood of human injury based on the totality of the circumstances.
- C. Type Red (attack): An attack by a public safety wildlife species on a human resulting in physical contact, injury, or death.

These guidelines are not intended to address orphaned, injured, or sick wildlife which have not threatened public safety. To achieve the intent of these guidelines, the following procedures shall be used.

- A. Wildlife Incident Report Form. Fill out a Wildlife Incident Report Form (WMD-2) for all reports of public safety wildlife incidents. The nature of the report will determine the response or investigative action to the public safety problem. For those reports which require a follow-up field investigation, the Wildlife Incident Report Form will be completed by the field investigator. All completed Wildlife Incident Report Forms shall be forwarded through the regional offices to the Chief, Wildlife Programs Branch (WPB).
- B. Response to Public Safety Wildlife Problems

The steps in responding to a public safety wildlife incident are diagrammed below:



Any reported imminent threats or attacks on humans by wildlife will require a follow-up field investigation.

If a public safety wildlife species is outside its natural habitat and in an area where it could become a public safety problem, and if approved by the Deputy Director for the Wildlife and Inland Fisheries Division (WIFD), it may be captured using restraint techniques approved by the Wildlife Investigations Laboratory (WIL). The disposition of the captured wildlife may be coordinated with WIL.

- A. Type Green (sighting). If the investigator determines that no imminent threat to public safety exists, the incident is considered a Type Green. The appropriate action may include providing wildlife behavior information and mailing public educational materials to the reporting party.
- B. Type Yellow (threat). Once the field investigator finds evidence of the public safety wildlife and perceives the animal to be an imminent threat to public health or safety, the incident is considered a Type Yellow. In the event of threat to public safety, any Department employee responding to a reported public safety incident may take whatever action is deemed necessary within the scope of the employee's authority to protect public safety. When evidence shows that a wild animal is an imminent threat to public safety, that wild animal shall be humanely euthanized (shot, killed, dispatched, destroyed, etc.). For Type Yellow incidents, the following steps should be taken:
  - 1. Initiate the Incident Command System (ICS). The Incident Commander (IC) consults with the regional manager or designee to decide on the notification process on a case-by-case basis. Full notification includes: the field investigator's supervisor, the appropriate regional manager, the Deputy Director, WIFD, Chief, Conservation Education and Enforcement Branch (CEEB), Chief, WPB, WIL, Wildlife Forensics Lab (WFL), the designated regional information officer, and the local law enforcement agency.

2. If full notification is appropriate, notify Sacramento Dispatch at (916) 445-0045. Dispatch shall notify the above-mentioned personnel.
3. Secure the scene as appropriate. Take all practical steps to preserve potential evidence. The IC holds initial responsibility and authority over the scene, locating the animal, its resultant carcass, and any other physical evidence from the attack. The IC will ensure proper transfer and disposition of all physical evidence.
4. In most situations, it is important to locate the offending animal as soon as practical. WIL may be of assistance. The services of USDA, Wildlife Services (WS) can be arranged by the regional manager or designee contacting the local WS District Supervisor. If possible, avoid shooting the animal in the head to preserve evidence.
5. If an animal is killed, the IC will decide on the notification process and notify Sacramento Dispatch if appropriate. Use clean protective gloves while handling the carcass. Place the carcass inside a protective durable body bag (avoid dragging the carcass, if possible).

### C. Type Red (attack)

In the event of an attack, the responding Department employee may take any action necessary that is within the scope of the employee's authority to protect public safety. When evidence shows that a wild animal has made an unprovoked attack on a human, that wild animal shall be humanely euthanized (shot, killed, dispatched, destroyed, etc.). For Type Red incidents, the following steps should be taken:

1. Ensure proper medical aid for the victim. Identify the victim (obtain the following, but not limited to: name, address, phone number).
2. Notify Sacramento Dispatch at (916) 445-0045. Dispatch shall notify the field investigator's supervisor, the appropriate regional manager, the Deputy Director, WIFD, Chief, CEEB, Chief, WPB, WIL, WFL, the designated regional information officer, and the local law enforcement agency.
3. Initiate the Incident Command System. If a human death has occurred, an Enforcement Branch supervisor or specialist will respond to the Incident Command Post and assume the IC responsibilities. The IC holds initial responsibility and authority over the scene, locating the animal, its resultant carcass, and any other physical evidence from the attack. The IC will ensure proper transfer and disposition of all physical evidence.
4. Secure the area as needed. Treat the area as a crime scene. In order to expedite the capture of the offending animal and preserve as much on-scene evidence as possible, the area of the incident must be secured immediately by the initial responding officer. The area should be excluded from public access by use of flagging tape or similar tape (e.g., "Do Not Enter") utilized at crime scenes by local law enforcement agencies. One entry and exit port should be established. Only essential authorized personnel should be permitted in the excluded area. A second area outside the area of the incident should be established as the command post.
5. In cases involving a human death, WFL personnel will direct the gathering of evidence. Secure items such as clothing, tents, sleeping bags, objects used for defense

- during the attack, objects chewed on by the animal, or any other materials which may possess the attacking animal's saliva, hair, or blood.
6. If the victim is alive, advise the attending medical personnel about the Carnivore Attack-Victim Sampling Kit for collecting possible animal saliva stains or hair that might still be on the victim. If the victim is dead, advise the medical examiner of this evidence need. This sampling kit may be obtained from the WFL.
  7. It is essential to locate the offending animal as soon as practical. WIL may be of assistance. The services of WS can be arranged by the regional manager or designee contacting the local WS District Supervisor. If possible, avoid shooting the animal in the head to preserve evidence.
  8. If an animal is killed, the IC will notify Sacramento Dispatch. Treat the carcass as evidence. Use clean protective gloves and (if possible) a face mask while handling the carcass. Be guided by the need to protect the animal's external body from: loss of bloodstains or other such physical evidence originating from the victim; contamination by the animal's own blood; and contamination by the human handler's hair, sweat, saliva, skin cells, etc. Tape paper bags over the head and paws, then tape plastic bags over the paper bags. Plug wounds with tight gauze to minimize contamination of the animal with its own blood. Place the carcass inside a protective durable body bag (avoid dragging the carcass, if possible).
  9. WFL will receive from the IC and/or directly obtain all pertinent physical evidence concerning the primary questions of authenticity of the attack and identity of the offending animal. WFL has first access and authority over the carcass after the IC. WFL will immediately contact and coordinate with the county health department the acquisition of appropriate samples for rabies testing. Once WFL has secured the necessary forensic samples, they will then release authority over the carcass to WIL for disease studies.
  10. An independent diagnostic laboratory approved by WIL will conduct necropsy and disease studies on the carcass. The WIL will retain primary authority over this aspect of the carcass.

#### D Responsibilities of WIL

WIL investigates wildlife disease problems statewide and provides information on the occurrence of both enzootic and epizootic disease in wildlife populations. Specimens involved in suspected disease problems are submitted to WIL for necropsy and disease studies. Most animals killed for public safety reasons will be necropsied to assess the status of health and whether the presence of disease may have caused the aggressive and/or unusual behavior.

Type Yellow public safety animals killed may be necropsied by WIL or an independent diagnostic laboratory approved by WIL. Contact WIL immediately after a public safety animal is killed to determine where it will be necropsied. Arrangements are to be made directly with WIL prior to submission of the carcass to any laboratory.

Type Red public safety animals killed will be necropsied by an independent diagnostic laboratory approved by WIL. Contact WIL prior to submission of the **carcass to any** laboratory to allow the Department veterinarian to discuss the disease testing

requirements with the attending pathologist. A disease testing protocol has been developed for use with Type Red public safety wildlife.

## E Responsibilities of WFL

WFL has the statewide responsibility to receive, collect, examine and analyze physical evidence, issue reports on evidence findings, and testify in court as to those results. WFL's primary function in public safety incidents is to verify or refute the authenticity of the purported attack and to corroborate or refute the involvement of the suspected offending animal.

Type Yellow public safety animals killed may be examined by WFL personnel. The examination of the carcass will be coordinated with WIL.

All Type Red public safety animals killed must be examined by WFL personnel or a qualified person approved by WFL supervisor using specific procedures established by WFL.

If a human death occurs, coordination of the autopsy between the proper officials and WFL is important so that WFL personnel can be present during the autopsy for appropriate sampling and examination. In the event of human injury, it is important for WFL to gather any relevant physical evidence that may corroborate the authenticity of a wildlife attack, prior to the treatment of injuries, if practical. If not practical, directions for sampling may be given over the telephone to the emergency room doctor by WFL.

## F Media Contact

Public safety wildlife incidents attract significant media attention. Issues regarding site access, information dissemination, the public's safety, carcass viewing and requests to survey the scene can be handled by a designated employee. Each region shall designate an employee with necessary ICS training to respond as a regional information officer to public safety wildlife incidents.

Type Yellow public safety wildlife incidents may require the notification of a designated employee previously approved by the regional manager or designee to assist the IC in responding to the media and disseminating information. The IC has the authority to decide if the designated employee should be dispatched to the site.

All Type Red public safety wildlife incidents require that a designated employee, previously approved by the regional manager or designee, to assist the IC in responding to the media and disseminating information, is called to the scene.

The Department will develop and provide training for designated employees to serve as information officers for public safety wildlife incidents.

## Montana Mountain Lion Status Report

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**ABSTRACT** The total harvest of mountain lion in Montana in 2007 was 309. This represents a slight increase from 2006. Northwest Montana completed its second year of limited entry-only hunting for pumas with female sub-quotas. Approximately 70% of the permits offered in northwest Montana were filled, with the female puma harvest representing 20%. The region is experimenting with incorporating life-history metrics from long-term puma research projects to manage populations. Region 2 based out of Missoula will be implementing limited-entry permit hunting for pumas in 2008. In Montana, when hunting is offered via limited-entry permits, non-residents are limited to 10% of the permits offered via the drawing. In addition to habitat conservation projects, Montana's two issues for the future are how to appropriately apply the results of long-term puma research to set hunting seasons with our Fish, Wildlife, and Parks Commission and to maintain tolerance through the work of conflict specialists and existing staff for this highly prized game animal. Montana is also planning on completing and publishing the Garnet Mountain Puma Research Project and updating the 1996 Puma Management Plan.

## Wyoming Mountain Lion Status Report

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David S. Moody, Trophy Game Section Coordinator, Wyoming Game and Fish Department, 260 Buena Vista, Lander, WY 82520, USA, [Dave.Moody@wgf.state.wy.us](mailto:Dave.Moody@wgf.state.wy.us)  
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Similar to management of mountain lions and other large carnivores across North America, the management of mountain lions in Wyoming has evolved considerably since European exploration and settlement. Initial steps towards “management” dealt with placing bounties on mountain lions and other predators in 1882, with unlimited bag limits and year-round seasons. In 1973, the mountain lion was classified as a trophy game animal in Wyoming, which allowed for state management as well as holding the Wyoming Game and Fish Department (WGFD) fiscally liable for confirmed livestock losses attributed to mountain lions. The following year, the first hunting season for mountain lions was instituted, with the entire state as one hunt area and an individual bag limit of one lion per year. Kittens and females with kittens present were protected, and hunters were required to present skulls and pelts to the nearest WGFD District Office or local game warden. Since the initial harvest season of mountain lions in Wyoming the management plan has evolved to include all pertinent information related to cougar population demographics as well as social attitudes and public input towards management of mountain lions within the state.

In 2007, a new mountain lion management plan (WGFD 2006) was implemented, which incorporated suggestions put forth in the cougar management guidelines (Cougar Management Guidelines Working Group [CMGWG] 2005). Most notably, the new plan called for managing mountain lions in an adaptive management scheme based on regional input and biological aspects associated with habitat of hunt areas and mountain lion management units (MLMUs). Hunt areas were classified as source, sink, or stable based on lion mortality sex/age criteria. Issues related to human/lion conflicts, livestock depredation, and habit quality related to prey availability were also included in developing management objectives for hunt areas. The adaptive management plan for mountain lions in Wyoming is aimed at sustaining mountain lion populations throughout suitable habitat at varying densities depending on management objectives, to provide for recreational/hunting opportunity, and to minimize mountain lion depredation and the potential for human injury throughout the state.

### Distribution and Abundance

Mountain lions are distributed statewide at varying densities depending on habitat quality, prey abundance and availability, and intra/interspecific competition. In some areas of the state, mountain lions coexist with black bears (*Ursus americanus*), grizzly bears (*Ursus arctos*), and wolves (*Canis lupus*), which may affect movement patterns or spatial/temporal variations. Lion densities are generally higher in portions of the state where large tracts of contiguous lion habitat occur, with lower densities occurring in the grasslands of northeastern Wyoming and across the

Red Desert basin. Mixed conifer and mountain mahogany habitats are used for stalking cover (Logan and Irwin 1985). Based on habitat modeling, mountain lions used edge habitats related to prey density as well as making seasonal shifts to follow ungulate movements. During the winter, mountain lions were found at lower elevations and concentrated their use near the timber/prairie interface (Anderson 2003). We continue to assess habitat suitability of mountain lions and will update the Wyoming habitat model to include areas in northeastern and southwestern Wyoming. As human sprawl and energy development increase throughout the state, effects of habitat alteration on mountain lions is an issue that may need further assessment.

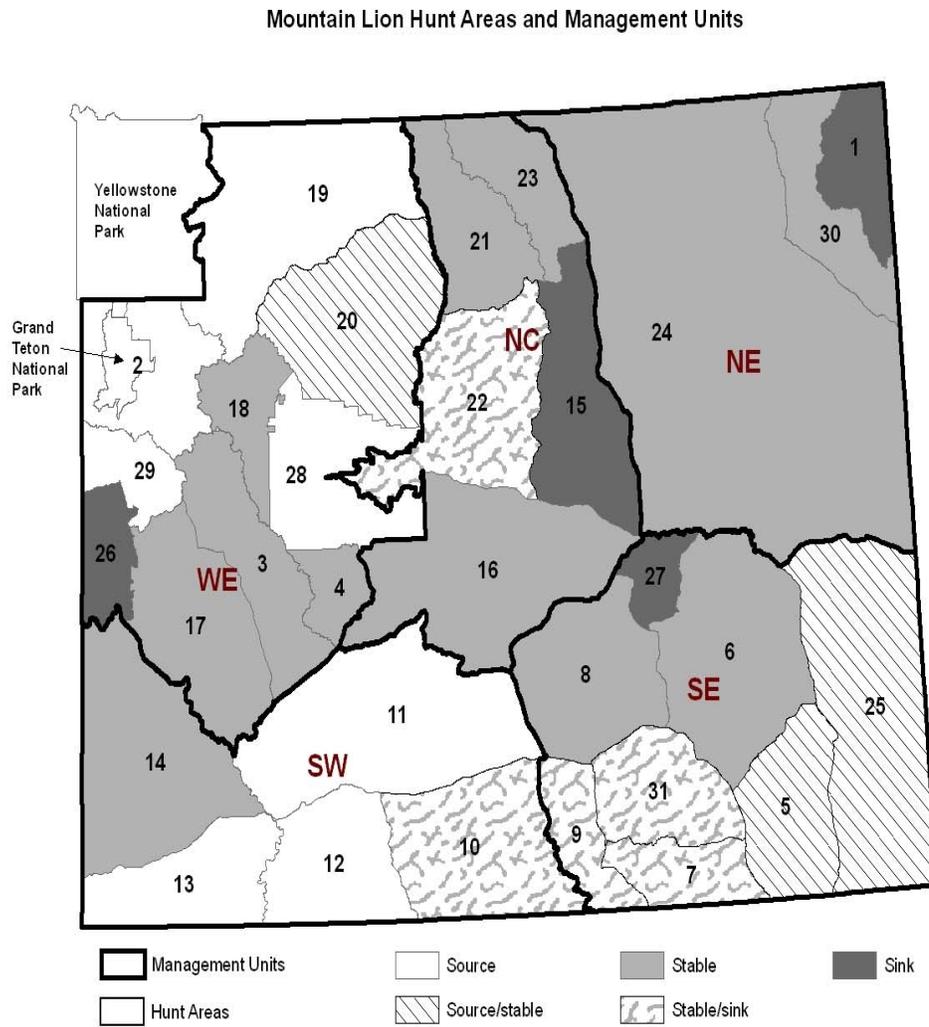
## **Harvest and Management**

Mortality data on mountain lions are gathered annually among 31 hunt areas that are grouped in five MLMUs (Fig. 1.) The number of hunt areas increased from 29 to 31 in hunt year 2007. The additional hunt areas came as a result of splitting two existing hunt areas in order to better address regional concerns. The boundaries of MLMUs encompass large areas with contiguous habitat and topographic features and are believed to surround population centers. Each hunt area has a maximum mortality quota that varies from 2-25 animals, with 3 areas also having a maximum female harvest limit (Table 1). If the quota is filled (total or female), the hunt area automatically closes. During mandatory inspections of harvested animals, many variables are recorded, including: harvest date, location, sex, lactation status, estimated age, number of days spent hunting, use of dogs, other lions observed, as well as several other parameters. Skulls and pelts must be presented in unfrozen condition so teeth can be removed as well as providing evidence of sex and lactation status. The information gathered during inspection is used to assess sex/age structure of harvested animals. Beginning in 2007, all known human-caused mortality events counted towards the quota; prior to this, only legal and illegal mortalities counted towards the quota.

Legal shooting hours are from one-half hour before sunrise to one-half hour after sunset. The individual bag limit is one lion per hunter per calendar year, (except in one hunt area where an additional animal may be taken). Kittens and females with kittens at side are protected from harvest. Dogs may be used to take lions during open seasons only, with no pursuit season in Wyoming. Hunters are responsible for knowing about quota status of hunt areas by calling a toll-free telephone number prior to entering the field. Current prices for tags are \$25.00 for residents and \$301.00 for nonresidents. Additional licenses (for the one hunt area) are \$16.00 and \$76.00 for residents and nonresidents, respectively.

The WGFDD does not estimate lion population numbers. Rather, population trends are assessed through sex and age composition of mortality data (Anderson and Lindzey 2005). Management objectives for MLMUs and hunt areas are determined by balancing public demands (i.e., human/lion interactions, livestock depredation, and adequate hunting/viewing opportunity) and biological requirements for sustainable lion populations throughout the landscape. The sex and age composition of harvested lions is compiled and analyzed statewide, for each MLMU and for each hunt area. Analyzing data by management units allows managers to evaluate harvest within specific hunt areas and the effect harvest has on the regional population. If observed trends are consistent with objectives set forth for each hunt area, changes in quotas are not recommended.

However, if trends deviate from hunt area objectives, quota increases or decreases may be recommended.



**Figure 1.** Mountain lion management units and hunt areas in Wyoming, 2007.

**Table 1.** Wyoming mountain lion management units, hunt areas, season dates and annual quotas for hunt year 2007.

Mountain Lion Management Unit	Hunt Area	Season Dates	Annual Mortality Quota	Annual Female Mortality Quota
Northeast	1	Sept. 1-Mar. 31	16	
	24	Sept. 1-Mar. 31	4	
	30	Sept. 1-Mar. 31	8	
Southeast	5	Sept. 1-Mar. 31	12	
	6	Sept. 1-Mar. 31	12	
	7	Sept. 1-Mar. 31	14	
	8	Sept. 1-Mar. 31	10	
	9	Sept. 1-Mar. 31	7	
	10	Sept. 1-Mar. 31	7	
	16	Sept. 1-Mar. 31	6	
	25	Sept. 1-Mar. 31	3	
	27	Sept. 1-Aug. 31	10	
31	Sept. 1-Aug. 31	6		
Southwest	11	Sept. 1-Mar. 31	2	
	12	Sept. 1-Mar. 31	6	3
	13	Sept. 1-Mar. 31	3	
North-Central	15	Sept. 1-Aug. 31	25	
	21	Sept. 1-Mar. 31	20	
	22	Sept. 1-Aug. 31	15	
	23	Sept. 1-Mar. 31	18	
West	2	Sept. 1-Mar. 31	7	3
	3	Sept. 1-Mar. 31	12	
	4	Sept. 1-Mar. 31	8	
	14	Sept. 1-Mar. 31	15	
	17	Sept. 1-Mar. 31	9	
	18	Sept. 1-Mar. 31	12	
	19	Sept. 1-Mar. 31	20	
	20	Sept. 1-Mar. 31	4	
	26	Sept. 1-Mar. 31	15	
	28	Sept. 1-Mar. 31	3	
	29	Sept. 1-Mar. 31	9	4

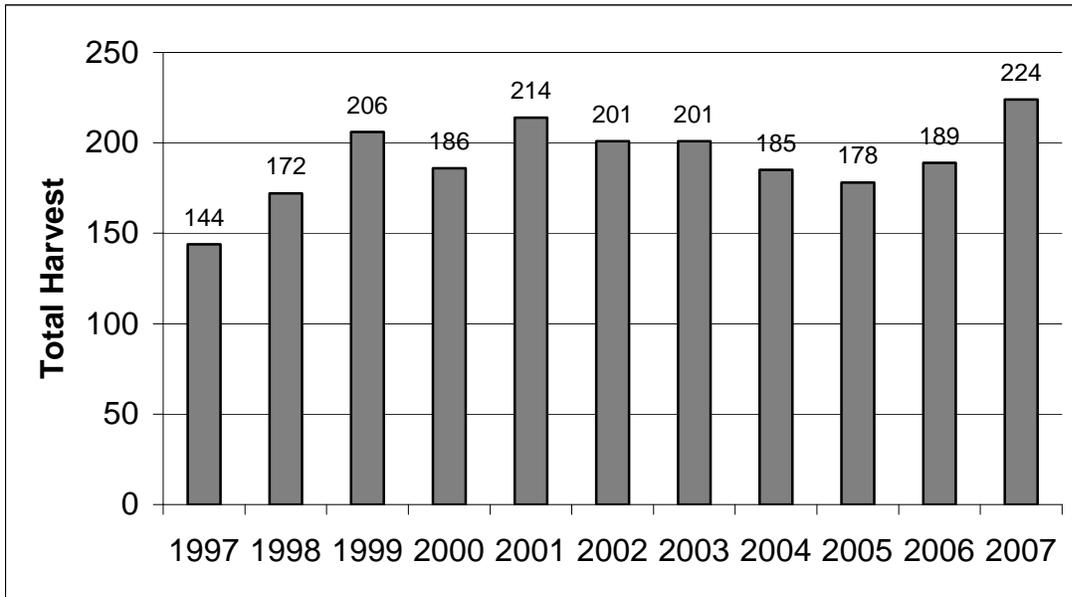
Mountain lion management was augmented beginning in 2007 after a new plan was adopted by the WGFD Commission, which fostered a regional management scheme based on source/sink/stable population dynamics (CMWG 2005). Managing for a combination of source, stable, and sink mountain lion subpopulations within MLMUs (i.e., at the hunt area level) will provide flexibility to address local management concerns (e.g., livestock depredation) while maintaining overall population viability on a landscape level and provide for long-term harvest and recreation opportunities.

Hunt area management objectives include:

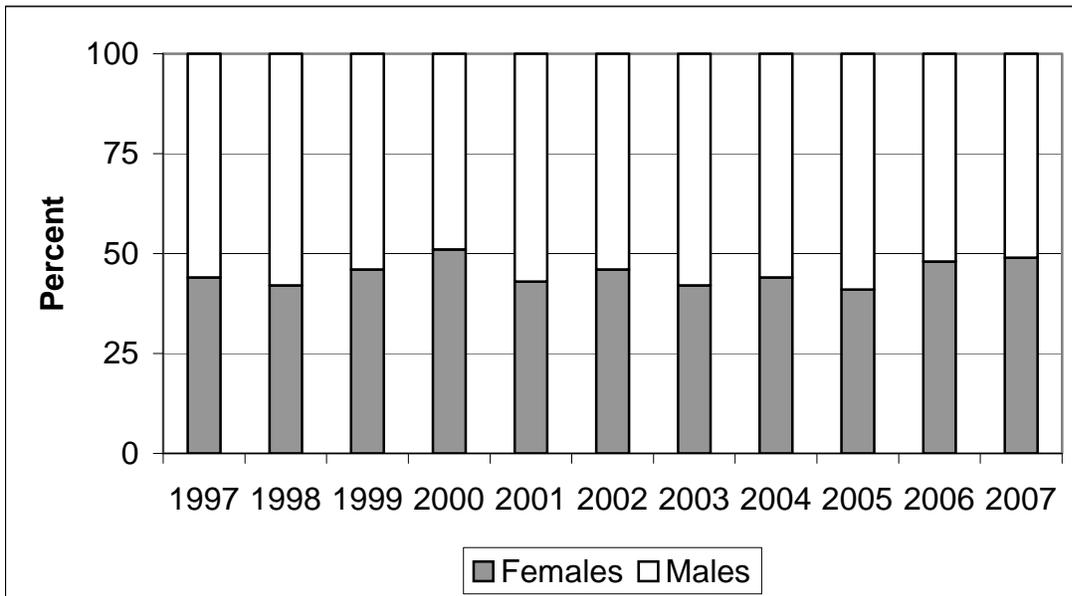
1. Manage to be a Sink: reduce mountain lion densities
  - a) Maintain density of human-caused mortality  $>8$  mountain lions/1,000 km<sup>2</sup> (386 mi<sup>2</sup>).
  - b) Achieve adult female harvest  $>25\%$  of total harvest for 2 seasons.
  - c) Progression in mean age of harvested adult females should decline to  $<5$  years old.
  
2. Manage to be a Source: maintain human-caused mortality levels that allow mountain lion population growth or maintain relatively high mountain lion densities that provide a source to other populations.
  - a) Maintain density of human-caused mortality  $<5$  mountain lions/1,000 km<sup>2</sup> (386 mi<sup>2</sup>)
  - b) Maintain adult female harvest  $<20\%$  of total harvest.
  - c) Maintain older-age adult females in the population ( $>5$  years old). This will be difficult to identify without additional sampling due to low sample size from harvest, but would be expected for lightly hunted populations.
  
3. Stable management: maximize long-term hunting opportunity and population viability.
  - a) Maintain human-caused mortality density between 5-8 mountain lions/1,000 km<sup>2</sup> (386 mi<sup>2</sup>)
  - b) Adult female harvest should not exceed 25% of total harvest for more than 1 season.
  - c) Maintain intermediate-aged adult females (mean  $\cong$  4-6 years old) in the harvest. Adequate age evaluation may require averaging age data over time to achieve meaningful sample sizes.

Statewide harvest increased from 1997 through 2001 and since then has tapered off (Fig. 2). Since 1997 Wyoming has averaged 190.9 cougars harvested annually. Hunt year 2007 had the highest harvest of the past ten years. However, in addition to higher quotas in some areas, all human-caused mortalities were included in the quota in 2007 rather than only legal/illegal kills. Preliminary results suggest total annual mortality does not appear to be significantly higher in 2007 compared to previous years. Since 1997, the average percent of females in the harvest has been 45%, ranging from 41% in 2005 to 51% in 2000 (Fig. 3). Since 1997, successful hunter effort has ranged from 3.3 to 4.1 days for an average of 3.6 days hunting per harvested animal

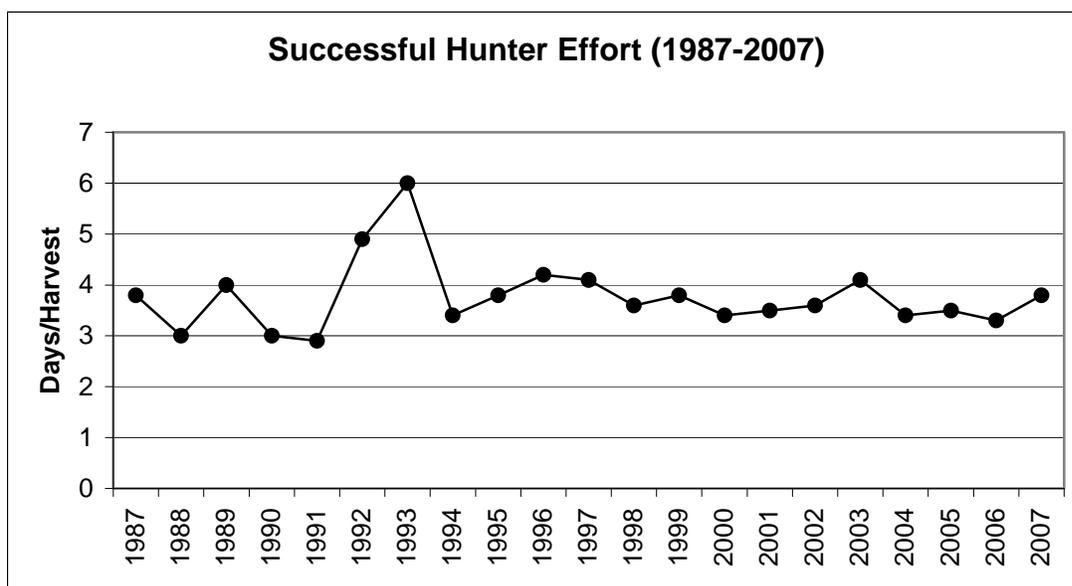
(Fig. 4). Approximately 90% of all successful hunters in Wyoming harvested lions with the aid of dogs from 1997-2007.



**Figure 2.** Total Wyoming mountain lion harvest, 1997-2007. (2007 hunt year initiates inclusion of all human-caused mortality.)



**Figure 3.** Percent male and female Wyoming mountain lion harvest, 1997-2007.



**Figure 4.** Successful hunter effort for Wyoming mountain lion hunters, 1987-2007.

### Depredation and Human Lion Interactions/Conflicts

Currently, Wyoming uses a statewide protocol for managing trophy game depredations and interactions with humans. A depredating lion is defined as a lion that injures or kills livestock or domestic pets. In addition, 4 types of human/mountain lion interactions are defined by the WGFD: 1) Recurring sighting – repeated sightings of a particular lion; 2) Encounter – an unexpected meeting between a human and a lion without incident; 3) Incident – an account of abnormal lion behavior that could have more serious results in the future (e.g., a lion attacking a pet, or a lion exhibiting aggressive behavior toward humans); and (4) Attack – human injury or death resulting from a lion attack. Each incident is handled on a case-by-case basis and is dealt with accordingly based on the location of the incident, the threat to human safety, the severity of the incident, and the number of incidents the animal has been involved in. Every effort is made to prevent unnecessary escalation of incidents through an ascending order of options and responsibilities (WGFD 1999):

- 1) No Management Action Taken
  - Informational packets are provided to the reporting party that describe mountain lion natural history and behavior, damage prevention tips, and what to do in the event of an encounter.
- 2) Deterrent Methods
  - Removal or securing of attractant
  - Removal of depredated carcass
  - Removal or protection of livestock
- 3) Aversive Conditioning

- Use of rubber bullets
  - Use of pepper spray
  - Use of noise-making devices or flashing lights
  - Informational packets provided to the reporting party
- 4) Trapping and Relocation
- If the above efforts do not deter the lion from the area, if public safety is compromised, if it is a first offense, or if it has been a lengthy span of time between offenses
  - Informational packets provided to the reporting party
- 5) Lethal Removal of the Animal by the WGFD or land owner
- If the above methods do not deter the lion, if public safety is compromised, or if the offending lion has been involved in multiple incidents in a short span of time
  - Wyoming statute 23-3-115 allows property owners or their employees and lessees to kill mountain lions damaging private property, given that they immediately notify the nearest game warden of the incident
  - Lions that have been removed from the population will be used for educational purposes
  - Informational packets provided to the reporting party

### **Information and Education**

Information and education regarding mountain lion ecology and management is a vital aspect of human/mountain lion interaction prevention, and a pivotal element of mountain lion management in Wyoming. The WGFD works closely with hunters, outfitters, recreationalists, livestock operators, and homeowners in an attempt to minimize conflicts with large carnivores including lions. Every spring, the WGFD hosts “Living in Bear and Lion Country” workshops throughout the state to inform the public about bear and lion ecology, front and back-country food storage techniques, and what to do in the event of an encounter with a bear or lion. In addition, numerous presentations are given throughout the year to civic, private, and school groups. Media outlets are also used to inform, and in rare incidents warn, the general public about bear and lion safety issues and any recent sightings.

Despite the educational efforts undertaken by the WGFD and preventive measures taken by the public, conflicts with mountain lions do occur. The number of mountain lion conflicts has ranged from 5-32 annually from 1997-2007. There have been a total of 183 mountain lion/human conflict reports in Wyoming since 1997 with no major injuries or deaths reported. Encounters represent the majority of reports ( $n=130$ ), followed by pet deprecations ( $n=32$ ) and aggression towards humans ( $n=13$ )

Wyoming statute 23-1-901 provides monetary compensation for confirmed livestock damage caused by mountain lions. The number of damage claims for the last 10 years ranged from 10 claims in 2005 to a high of 28 claims in 1998 (Table 2) Payments made to claimants range from a low of \$10,131 (2003) to a high of \$44,071 (1998; Table 2). The strong majority of mountain lion-livestock depredation issues in Wyoming are attributed to sheep. From 1997 to 2006, 94%

of damage compensations related to sheep, 2% involved horses, and 2% involved cattle. An average of 5 mountain lions was removed annually for depredation or human safety reasons over the past decade.

**Table 2.** Wyoming ten-year mountain lion damage claim and translocation/removal history.

<b>Year</b>	<b># Claims</b>	<b>\$ Claimed</b>	<b>\$ Paid</b>	<b># Translocations</b>	<b># Removals</b>
1997	20	28,935.16	28,761.50	1	10
1998	28	56,171.39	44,070.79	2	5
1999	21	32,307.63	22,627.43	2	6
2000	20	42,352.69	30,773.59	0	5
2001	15	38,322.79	25,592.46	1	6
2002	13	35,870.99	32,075.05	0	2
2003	21	13,688.89	10,130.86	1	1
2004	14	25,680.30	23,449.73	0	3
2005	10	41,834.23	39,328.83	0	4
2006	12	21,949.37	18,502.53	1	7
Mean	17.4	33,711.34	27,531.28	0.8	4.9

### **Issues of Concern and What the Future Holds**

Livestock depredation attributed to lions, primarily on sheep, will always be an issue of contention that will be dealt with regarding lion management in Wyoming. Certain hunt areas are being managed as sink areas (reduced lion densities) and we will evaluate this management technique as it relates to the issue of livestock depredation.

While not considered an “issue” necessarily, human safety and human/mountain lion interactions are topics that are vigilantly addressed and monitored where people and mountain lions coexist. Educational efforts continue annually, and if warranted, will be increased to inform the public about mountain lion behavior and safety procedures that can be adopted in case of a mountain lion interaction. Efforts are made towards preventive methods (i.e., landscaping, husbandry techniques, outdoor awareness) that reduce the overall chance of mountain lion/human encounters. Education increases the ability of co-existence of the species.

The management plan currently being used by WGFD is new and therefore assessment of the adaptive techniques involved is critical in order to evaluate the overall effectiveness. We will assess differences related to conflict and depredation issues between the different harvest objectives (e.g., source vs. sink) and evaluate hunter success rates and effort. We plan to implement additional field research in areas of the state where data are needed, as well as modeling habitat in regions of the state where data need augmentation.

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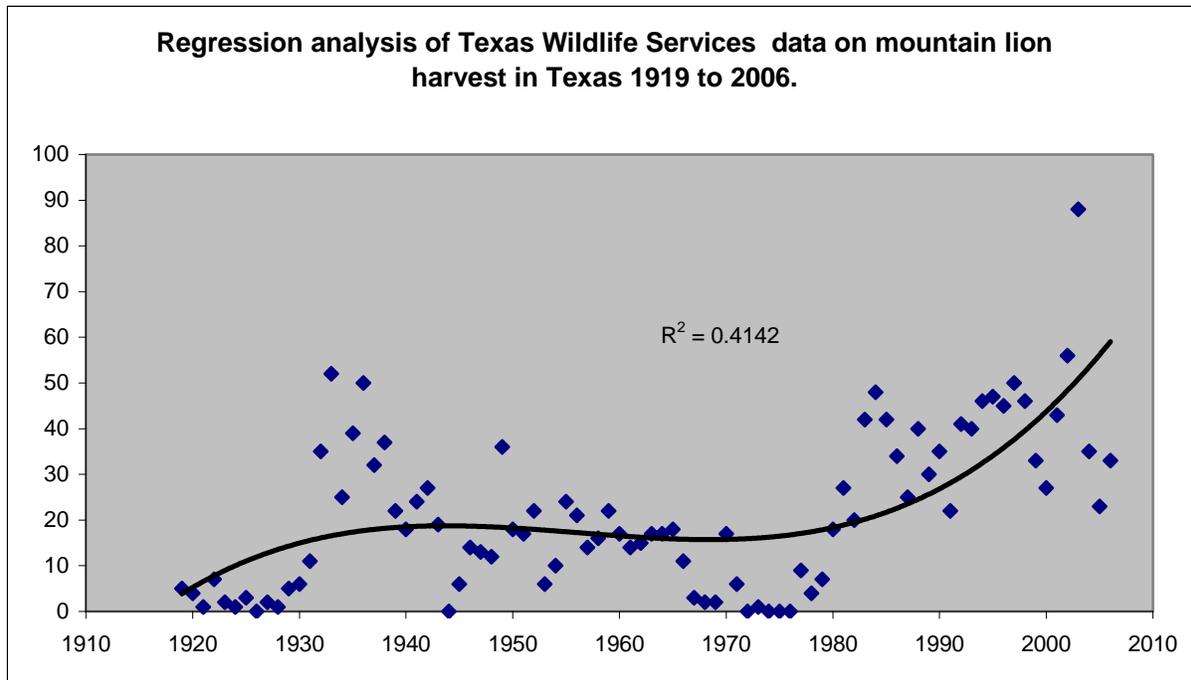
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# Texas Mountain Lion Status Report

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## Population Trends

Indirect measures of population abundance, such as harvest data, are often used to make inference on long-term population dynamics when direct data are either not available or are logistically difficult to obtain. Although harvest data has inherent problems in that it is dependent upon effort, not necessarily on whether the population is increasing or decreasing in number, Texas Wildlife Damage Management Service (TWDMS) provides a long-term dataset for trend analysis. TWDMS responds to wildlife damage complaints. Assuming that damage complaints and removals would increase with an increasing mountain lion population, TWDMS harvest data indicates a significant increasing number of mountain lions being removed from 1919 to 2006 ( $R^2 = 0.25$ ,  $P < 0.001$ ). There are 2 evident periods where harvest increased; 1920 thru 1940 ( $R^2 = 0.501$ ,  $P = 0.0002$ ) and 1970 thru 2003 ( $R^2 = 0.53$ ,  $P = 0.002$ ). Trend analysis tells whether a particular data set has increased or decreased over a period of time, although it suffers from a lack of scientific validity in cases where other potential changes (e.g., effort, funding, and nonrandom sampling) can hinder estimation (Fig. 1).



**Figure 1.** Polynomial regression analysis of harvest data from Texas Wildlife Services from 1919 to 2006.

## **Genetic Monitoring**

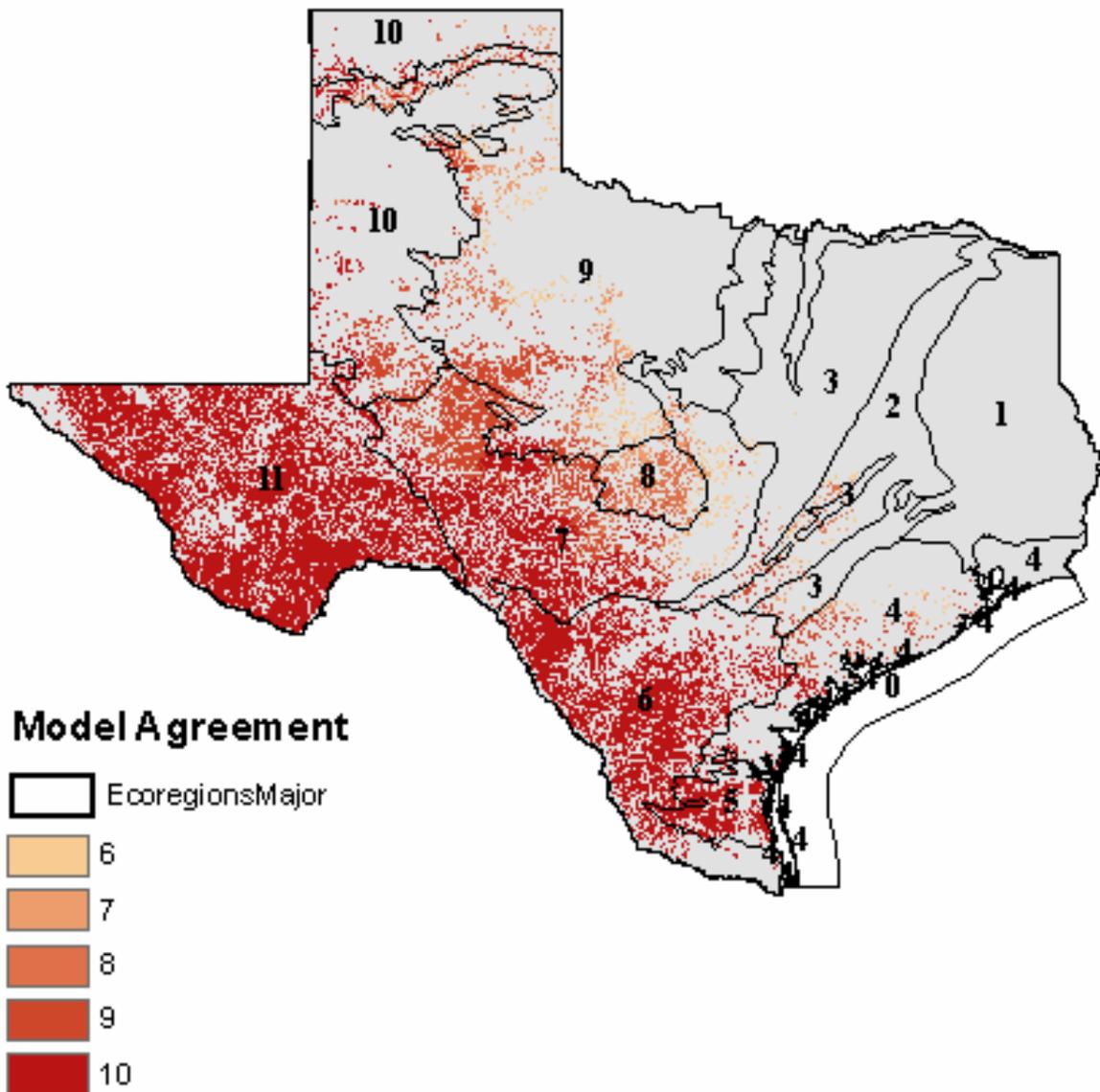
A recent study by Janecka et al. (In review) provides some insight into mountain lion population structure and genetic diversity. Analysis of 18 microsatellite loci in 89 mountain lions revealed moderate levels of genetic variation ( $H_o = 0.36-0.48$ ) characteristic of mountain lion populations in North America. Long-term effective population size for mountain lion in Texas was estimated to be 5,607 animals. This is well in excess of 500 animals which is the proposed minimum effective population size (Franklin 1980) for long-term population viability and is comparable to estimates for mountain lion in Wyoming ( $N_e = 4,532$ ) (Anderson 2004) and Utah ( $N_e = 5,732$ ) (Sinclair et al. 2001). However, these estimates need to be interpreted with caution because they reflect long-term effective population size and not current population size. The patterns in genetic variation suggest mountain lions in Texas exist as metapopulations and the populations between South Texas and the Trans-Pecos are isolated by distance. Further investigation into genetic variation using bone samples from historic mountain lion samples in museums will provide an opportunity to evaluate changes in genetic diversity over time but is currently dependent upon available research funding and may take some time to complete.

## **Distribution Prediction**

Recently we have utilized ecological niche modeling and the Genetic Algorithm for Rule Set Production (GARP) to estimate potential distribution of mountain lion in Texas (John Young, unpublished data). A predicted niche area was developed using GARP, mountain lion occurrences throughout the US, and environmental coverage information for the US. Texas was then extracted and the prediction was refined by eliminating portions of the predicted niche using roads, urban areas, and land use-land cover (Martinez-Meyer et al., 2006). At the 1-km<sup>2</sup> spatial scale, GARP predicts potential mountain lion distribution in Texas in the Trans-Pecos, Edwards Plateau, South Texas, Llano Uplift, southern Rolling and High Plains and disjunct areas in the northern High and Rolling Plains, Blackland Prairie, Oak Woods and Prairies, and Gulf Coastal Plains Ecoregions (Fig. 2). Although our model predicts potential distribution in areas of Texas where mountain lions have not been recently confirmed (e.g., Gulf Coastal Plains), Peterson (2006) states that some suitable areas are expected to be uninhabited and does not necessarily imply over-prediction. While GARP predicts an appropriate ecological niche in the Gulf Coastal Plains, Blackland Prairie, and Oak Woods and Prairie Ecoregions, the density of roads and human residence make it unlikely that resident mountain lions are present (Van Dyke et al. 1986, Beier 1996).

## **Human Interaction Protocol**

In 2006, due to concerns over an apparent increase in mountain lion sightings in suburban and urban areas, TPWD convened a panel to develop a Mountain Lion Human Interaction Protocol. A protocol was implemented in January 2007 and a formalized database for recording sightings and human interactions was developed. The protocol established interaction classes, defined aggressive behavior and no-tolerance zones, and guidelines for response based on interaction classes were developed. In 2007, staff recorded 119 cases regarding mountain lions from within urban/suburban areas; 35 (29%) resulted in a formal field investigation.



**Figure 2.** Predicted distribution of mountain lions in Texas based on ecological niche modeling with the genetic algorithm for rule-set production. The 11 Ecoregions are: (1) the Pineywoods, (2) Oak Woods and Prairies, (3) Blackland Prairie, (4) Gulf Coast Prairies and Marshes, (5) Coastal Sand Plain, (6) South Texas Plains, (7) Edwards Plateau, (8) Llano Uplift, (9) Rolling Plains, (10) High Plains, and (11) Trans-Pecos. Darker colors mean greater likelihood of mountain lion presence.

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## **Nevada Mountain Lion Status Report**

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### **Cougar Management Plan**

The Nevada Cougar Management Plan aims to maintain cougar distribution in reasonable densities throughout Nevada. Objectives and goals include, for example, the removal of cougars that potentially represent a public safety hazard or are causing property damage, and the conservation of cougars to provide recreational, educational and scientific opportunities. Additional goals include maintaining a balance between cougars and their prey, and finally to manage cougars as a meta-population (Stiver 1995).

### **Distribution and Abundance**

Nevada is a mosaic of landscapes. Cougars seem well-adapted to the wide variety of habitat and environmental conditions. They are known to exist or wander through almost every mountain range from the Mojave Desert in extreme southern Nevada to alpine forests at the highest elevations in the northern part of the state. Distribution appears to be primarily influenced by prey availability. Distribution has remained fairly consistent through time as cougars are known to inhabit every Game Management Unit and every major mountain range in the state. Local densities, however, have been variable over time.

### **History of Nevada's Cougar Prey Base**

Bighorn Sheep (*Ovis canadensis*) were likely the most common of the large ungulate species within the state, inhabiting nearly every mountain range of Nevada (Cowan 1940, Hall 1946, Beuchner 1960, McQuivey 1978). Archeological investigations based on osteological records and petroglyphs have shown bighorns to be one of the more numerous and most widely distributed large ungulates throughout prehistoric Nevada (Harrington 1933, Jennings 1957, Gruhn 1976). After settlement, bighorn sheep populations dwindled under heavy hunting pressure and competition with non-native ungulates (NDOW 2001).

Mule deer (*Odocoileus hemionus*) were more limited in range and density within the state. A review of archeological records indicates that in nearly every site, deer remains were conspicuously absent or rare (Harrington 1933, Schroeder 1952, Jennings 1957, Shutler and Shutler 1963, Gruhn 1976). Only two site investigations in Nevada found mule deer to be a significant contributor to archeological middens (Fowler et al. 1973). Both of these locations occur in the northeastern corner of the state. Aldous (1945) noted that prior to 1925, mule deer were not noticeably abundant anywhere in the Intermountain states.

Mule deer and bighorn sheep hunting were closed by the 1901 state legislature due to subsistence overhunting by miners and other settlers (Hess 1998). Deer hunting was closed for two years while bighorn hunting remained closed for 51 years.

Historical records indicate that prey levels were inadequate to harbor large cougar populations in Nevada (Hall 1946). In 1915, a federal predator control program was initiated in the state. From 1917-1931, only 46 cougars were reported taken by the federal program (Woolstenhulme 2003, USDA reports 1915 -1949). During the years 1950 through 1959, this program accounted for the removal of 988 cougars, an average 99 per year. During the 34-year period (1915-1949), 115 cougars were removed. Simultaneously, USDA trappers reportedly removed 195,320 other predatory animals (Woolstenhulme 2003, USDA Reports 1915 -1949). Given the intensity of predator control for livestock protection, it is reasonable to infer that if cougars had been common a greater number would have been taken or reported.

Domestic sheep became a part of the prey base during the latter part of the 1800s and early 1900s. Huge numbers of these alternative prey species were being introduced into Nevada providing another viable food source for cougars. Nevada tax assessment rolls indicate the number of domestic sheep in Nevada rose from 33,000 in 1870 to 259,000 in 1880 (Elliot 1973). During the first thirty years of the 20<sup>th</sup> century domestic sheep numbers continued to increase, records indicating that the number of sheep in the state reached between 2 and 4.5 million head (Georgetta 1972, Lane 1974, Meaker 1981, Rowley 1985).

Leopold et al. (1945) and Aldous (1945) documented mule deer irruptions occurring in several locations in Nevada during the 1940's, and hypothesized that these "irruptions" were a result of "buck-only" laws, predator control and habitat changes from logging and grazing. Mule deer numbers in Nevada continued to increase, peaking during the mid to late 1950s (Wasley 2004).

For mule deer, a period of decline occurred in the late 1950's. During this decline, numbers never approached historic lows. By the late 1970s, deer populations began to increase again state-wide with a tremendous spike occurring throughout the 1980s (Wasley 2004). By the time state-wide deer populations peaked in the late 1980s, their number had soared in excess of 200,000 (Wasley 2004).

As prey species began to increase, so did cougar numbers and populations were described as an uncommon denizen (Hall 1946, Cahalane 1964, Stiver 1988) had grown in numbers to over 1,000 strong by the early 1970s (Stiver 1988, NDOW 1995 unpublished data). When deer numbers peaked a decade and a half later, estimated cougar numbers in Nevada reached 4,000 (NDOW 1995 unpublished data).

Following the unusually high deer densities of the 1980s, various factors including drought, habitat loss, habitat conversion, range fires and winter kill in 1992–1993 caused deer populations to gradually decline throughout the state. Available evidence suggests that cougar numbers have not decreased proportionately to the deer herd decline. This probably reflects the abundance of alternative prey, including domestic livestock and increasing numbers of other large wild prey.

Over the last twenty years, elk (*Cervus elaphus*) numbers in Nevada have risen nearly 700% and now number 9,500 statewide (Nevada unpublished data 2007). Likewise, feral horse numbers have steadily increased since receiving federal protection and now number around 18,000 in Nevada. Bighorn sheep also continue to increase in the Nevada Mountains (NDOW 2007 unpublished data).

### **History of the Cougars Legal Classification**

In 1965, the cougar's legal classification in Nevada was changed by regulation from an unprotected predator to a game animal. The change in classification resulted in the requirement of a valid hunting license to hunt a cougar, along with some restrictions on the method of take (e.g., trapping was disallowed). This provision precluded the taking of cougars at any time other than from sunrise to sunset and it also defined legal weapons as shotgun, rifle, or bow and arrow. The season was further defined as either sex, year-round, no limit nor was a tag required.

In 1968, a tag requirement was instituted. This made possible the recording of sport hunter harvest.

In 1970, a limit of one cougar per person was set and a six-month season was established. It was then required that all harvested cougars be validated by a representative of the Department within five days after the kill. This regulation presented the Departments first real opportunity to collect biological data from individual cougars.

In 1972, the Nevada Department of Wildlife initiated a study of cougars as a part of the Ruby-Butte deer project in eastern Nevada. The objective was to determine the status of cougar populations within this high-density deer area, and to evaluate them in relation to deer populations. Within two years, this objective was changed to:

1. Establish population estimates of cougars by mountain range or management areas statewide,
2. Establish basic habitat requirements, and
3. Establish a harvest management program.

This program involved cougar monitoring from both land and air and was instrumental in expanding the life history information base, as well as providing an approach toward estimating the annual population status of cougars in key mountain ranges. The findings from this study were then used to formulate an approach towards estimating statewide cougar populations. The data have informed cougar management in Nevada since 1983 (Ashman et al. 1983).

In 1976, 26 cougar management areas were defined statewide, and a harvest quota was established for each to control the sport harvest. This Controlled Quota Hunt was the most restrictive season ever established for cougar in Nevada.

In 1979, the 26 cougar management areas were collapsed into six management areas, each with a specific harvest objective. Hunting in each unit was allowed until the predetermined numbers of cougars were harvested.

In 1981, the Harvest Objective hunting season concept was applied statewide. Initially this system required a hunter to obtain a free hunt permit for the opportunity to hunt in one (1) management area.

In 1994, hunters were allowed to obtain a free hunt permit that authorized the hunter to hunt in two (2) management areas until the established harvest objective was reached. Both of these permit systems allowed hunters to change management areas at will as long as the harvest objective had not been reached in the desired management area(s).

In 1995, the hunt permit approach was again modified to eliminate the physical issuance of a permit in favor of establishing a 1-800 telephone number. This system allowed hunters to hunt in any management area where the harvest objective had not been reached. The hunter was required; however, to call the number before hunting to determine which management area(s) were still open to hunting.

In 1997, changes were made to regulations aimed at increasing cougar harvest, while maintaining the integrity of the harvest objective limits system. Those changes included the reduction of tag fees, over-the-counter tag sales, increasing bag limits from one tag per hunter to two tags per hunter, and consolidation of some of the harvest unit groups.

In 1998, Nevada's southern region was modified to provide for a year-round hunting season on cougars. The entire state went to a year-round season in 2001.

In 2003, changes modified harvest unit groups from 24 groups throughout the state to three statewide regions corresponding with the Division's three management regions. The cougar season continues to be year-round but season dates were changed to March 1<sup>st</sup> of each year to the last day of February the following year, corresponding with the Nevada hunting license.

In 2008, cougar tags were made available online, with an added option of only purchasing a tag if you are not successful in drawing another big game tag.

### **Current Status**

Current cougar populations are believed to be stable (NDOW 2007 unpublished data). The ten-year harvest trend is down in most parts of the State; however the two-year average is above the trend line. Each region in the state exhibits unique characteristics for harvest as well as sex and age structures and are quite independent of each other. As a result of hunting conditions, harvest trends can be independent and unrelated to the actual number of cougars available. In just the last decade, harvest has fluctuated from a high of 210 to a low of 105 (NDOW 2007 unpublished data).

In 2007, legislation was introduced (Nevada Assembly Bill 256) to re-classify cougars as a predator. The proposed state legislative bill and the resulting controversy strongly indicate that research on cougars and interactions with their prey is expected in Nevada. While the bill was defeated, it garnered support from some sportsmen, some mule deer advocates, and several state legislators.

In 2002, Nevada Assembly Bill 291 was proposed by sportsmen to direct collection of a mandatory \$3 fee to tag applications to fund predation management, especially for the protection of mule deer and other big game species. The bill passed. Cougars are currently targeted reactively as well as preemptively for the protection and enhancement of mule deer and bighorn sheep.

The Department uses the best information available to identify when and where predation management is applied to reduce cougar predation on other wildlife resources. Follow-up assessments suggests that selective removal, either preemptively or reactively, has benefited bighorn. Results are less clear for the protection of mule deer.

Results of the most current management actions regarding cougar harvest have addressed the recommendations to increase harvest and hunter opportunity. The actions, discussed earlier, have had mixed results. Extending the season to a year-round harvest has had little impact. Hunting conditions during the summer months are generally poor, and few hunters take to the field. Most recently, the Department has increased the convenience of purchasing cougar tags, and this has substantially increased sales. Whether or not this translates into an increased cougar harvest is unclear and will be tracked.

Within the past decade, the largest effect on harvest was the move to Regional quotas instead of Management Area quotas. In the inaugural year, harvest was increased, as predicted and intended, especially in the historic “hotspots” for cougar hunters. Since that initial pulse following the change harvest has again stabilized.

### **Cougar Management**

Cougar populations are estimated utilizing a life table model (retrospective harvest/mortality). The model utilizes known harvest/mortality rates and recruitment rates (Greenly 1988, Stiver 1995) to calculate a retrospective estimate of minimum viable population size needed to sustain known harvest rates over the same time-period. It also incorporates prey availability as a parameter. Although no defined confidence limit is used, the confidence in this model is relatively high, based on the fact that harvest rates have continued over time at a constant rate without signs of extirpation. Based on our current estimation methods, cougar populations within Nevada are between 2,500-3,500 animals.

Cougars are also known to exist on many of the large land holdings which are closed to cougar hunting in Nevada. These include the complex of the Nellis Air Force Base, the Nevada Test Site, and the Desert National Wildlife Range, which exist as one large contiguous land block of over 19,000 km<sup>2</sup>.

Other non-hunted populations exist on the Sheldon National Wildlife Range comprising 2,355 km<sup>2</sup>. The Great Basin National Park also harbors a healthy cougar population. There are numerous other federally held installations throughout Nevada in the form of national parks, monuments and other military reserves that have non-hunted populations of cougars. In all,

more than 10% of Nevada's 286,298 km<sup>2</sup> is closed to cougar hunting. In addition, much of Nevada is so remote and the terrain so inhospitable for hunting that harvest is negligible.

Cougar harvest objectives are calculated for each administrative region on an annual basis using standardized methodology. Harvest objectives are calculated and recommended in order to achieve a specific management action over a short-term period (no more than two years). Management actions may be designed to increase, stabilize and maintain, or decrease cougar populations within each of the three administrative regions in Nevada.

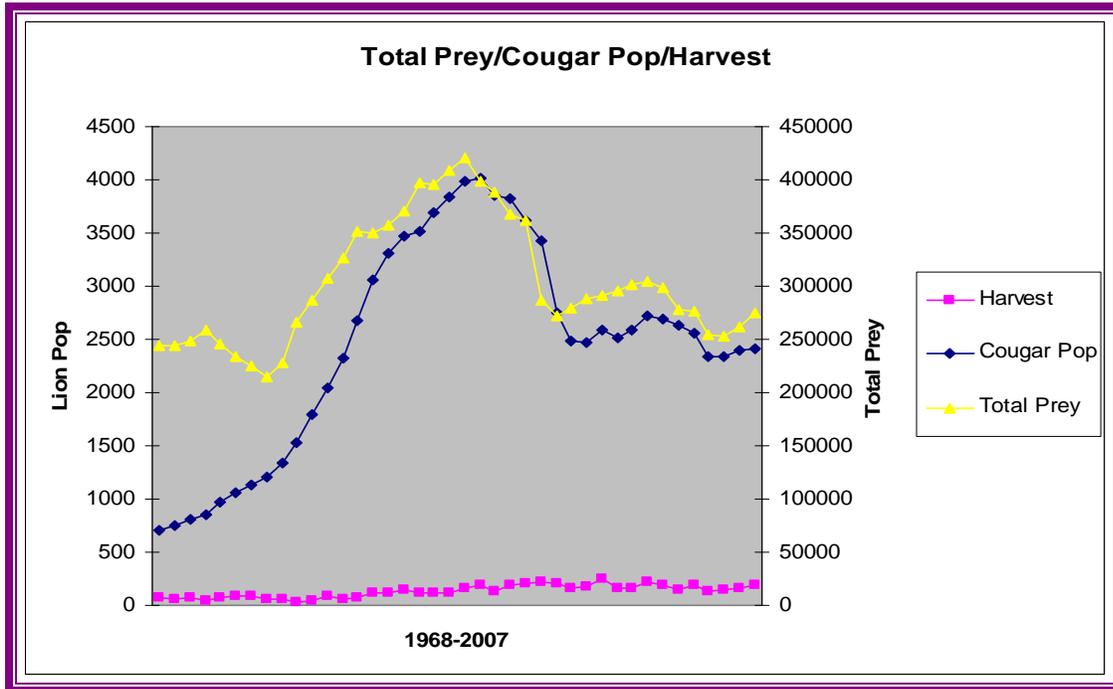
The ten-year harvest average is roughly 42% of statewide harvest objectives and represents only 6% of the current population estimate.

### **Cougar/Prey Relationship**

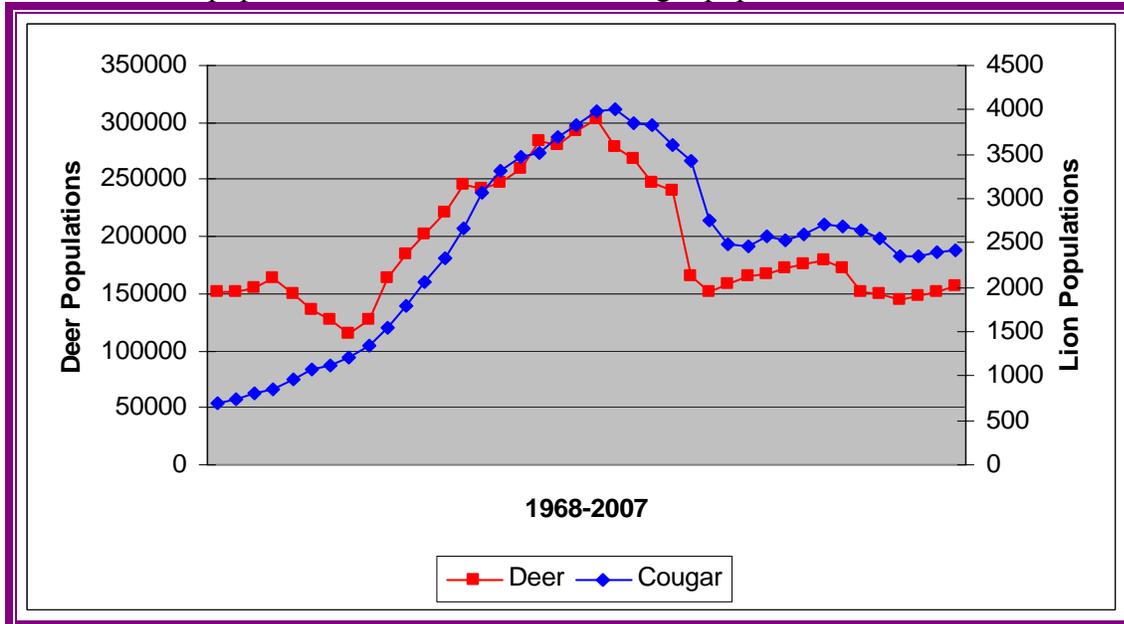
Table 1 represents a linear association with the total prey base that is available for cougar consumption with the associated cougar life table estimating population size. The bottom line represents harvest. The table dates back to 1968 and runs through 2007. The sharp apex coincides with the deer eruption experienced in the mid to latter 1980s and subsequently the decline of the 1990s (Wasley 2004). It is interesting to note that harvest did not spike during that same time nor did it valley subsequently. A small increase in harvest did occur through the 1990s as the deer numbers continued to decline. It is also interesting to note that statewide harvest did not significantly change as the model shows the cougar population aligning itself with the prey base.

Table 2 represents the deer-only aspect as it relates to the cougar model population estimates. The deer trend and the associated cougar estimates follow closely what one would expect until the cross-over. That point begins the increase of several of the alternative prey options. To date all alternative large prey species are still increasing, with deer somewhat stabilizing but at levels far below peak numbers.

**Table 1.** Total prey base as it relates to cougar population model estimates. The bottom line is harvest.



**Table 2.** Deer population trend as it relates to cougar population model estimates.



## **Future Research**

The Department is considering a graduate project to better quantify cougar distribution, abundance, and interactions with ungulate populations in Nevada. The departmental approach to this potential research is an “open-ended” study so that future studies in other parts of the State can contiguously tie into the ongoing effort.

The primary objectives of the study will revolve around four areas of consideration. Those are:

1. Examine the genetic structure of cougars within Nevada and across state lines to identify distinct sub-populations and determine whether they interact as a “meta-population”.
2. Examine prey species selection and kill rates of radio-tagged cougars in select sub-populations.
3. Refine and validate the NDOW cougar population model through extensive ground truthing of model parameters and “spot checking” to test model accuracy.
4. Determine the relative influence of immigration (including source/sink dynamics), prey densities, habitat, roads, hunting pressure, human population growth and other potentially relevant factors in regulating cougar distribution and abundance in different areas of Nevada.

The Nevada Department of Wildlife has been collecting DNA samples from harvested cougars for approximately four years and has over 500 samples. In 2002, the Department began the use of Matson laboratories to acquire more accurate lion age analysis. These age analyses are compared to age estimates provided by field personnel. Ironically, age in both sexes is generally overestimated with males being over aged at a higher rate than females, but the overall averages reveal the field personnel estimates are reasonably accurate (Lansford unpublished data). The teeth are extracted by the Department at the check-in on a volunteer basis but the practice is well supported by the sportsmen. In the past a letter authenticating the age the sportsmen’s harvested cougar was sent to them in appreciation for the sample. The practice is being resurrected.

## **Conclusion**

As with all big game species in Nevada, cougar populations are carefully monitored for responses to harvest. The available data suggest the following:

1. Cougars in Nevada, while lower than peak numbers in the 1980’s, overall are well above historic levels.
2. Although deer populations and livestock numbers are declining range-wide across Nevada, other alternative prey species are increasing. It is important to understand how effective and efficient cougar populations are at prey switching.
3. The sex, age structure and harvest trends for different areas of the State are somewhat unique and dynamic and require management to reflect that in an adaptive strategy.
4. Research is needed to identify cougar dispersal patterns, corridors and relatedness through genetic structure.

5. The Department recognizes and supports research and integrates all available information into management plans; especially those which relate to identifying trends in population structure and landscape level changes that require timely and active management.
6. The Department will continue to closely evaluate projects where cougars are removed for ungulate enhancement.
7. The Department will continue to seek a balance in addressing sporting opportunity, prey impacts, public opinion with viable cougar populations.

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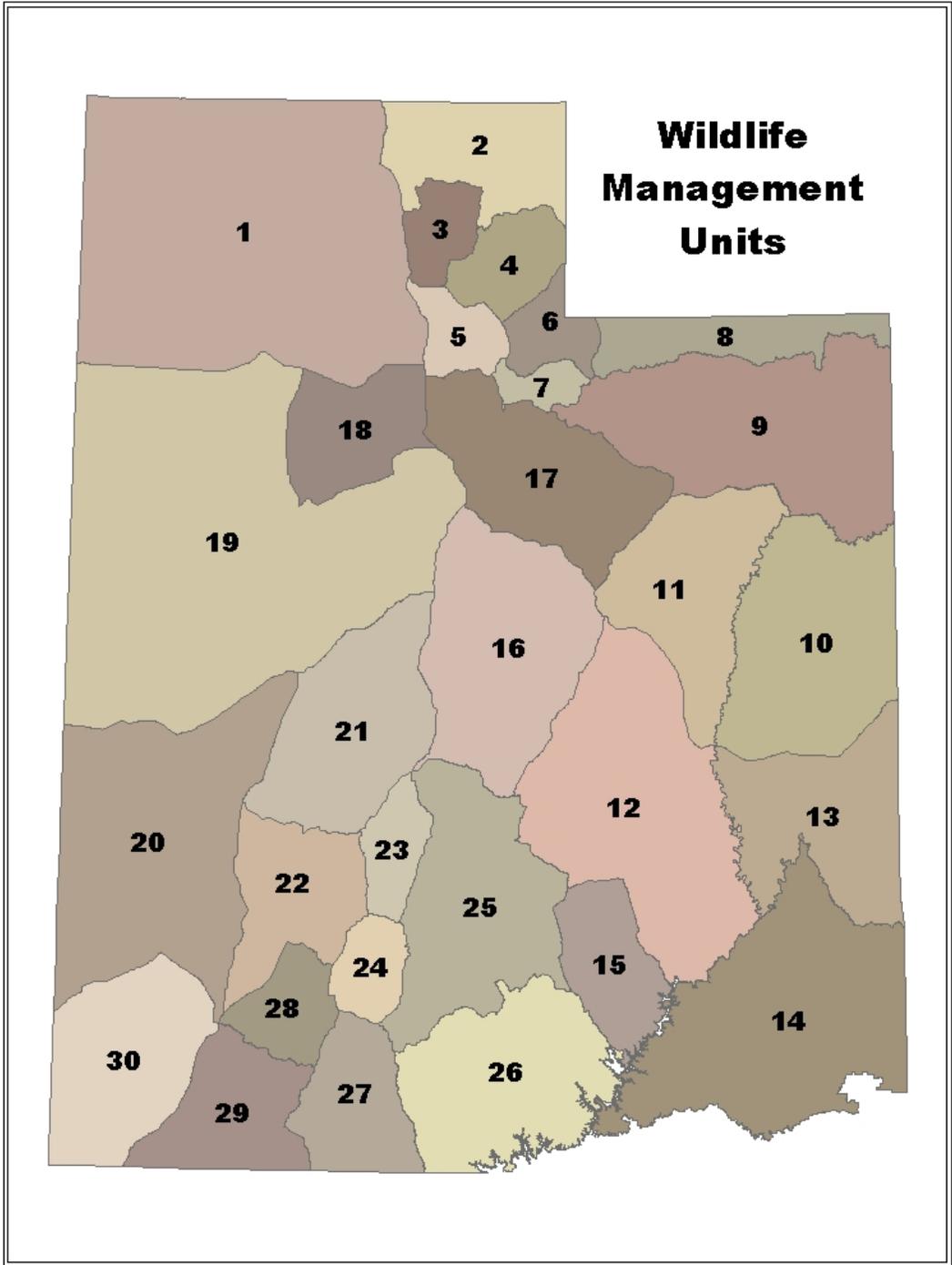
## Utah Mountain Lion Status Report

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Mountain lions (*Puma concolor*), or cougars, were persecuted as vermin in Utah from the time of European settlement (in 1847) until 1966. In 1967 the Utah State Legislature changed the status of cougars to protected wildlife and since then they have been considered a game species with established hunting regulations. The Utah Division of Wildlife Resources (UDWR) developed the Utah Cougar Management Plan in 1999 (UDWR 1999b) with the assistance of a Cougar Discussion Group composed of representatives of various public interest groups. This plan will guide cougar management in Utah through 2009. Its goal is to maintain a healthy cougar population within existing occupied habitat while considering human safety, economic concerns and other wildlife species. Management objectives include: 1) Maintaining current (1999) cougar distribution, with a reasonable proportion of older age animals and breeding females, balancing population numbers with other wildlife species; 2) Minimizing the loss in quality and quantity of existing critical and high priority cougar habitat; 3) Reducing the risk of loss of human life and reducing chances of injury by cougar; 4) Maintaining a downward trend in the number of livestock killed by cougar; and 5) Maintaining quality recreational opportunity for a minimum of 800 persons per year through 2009.

Utah's cougar harvests are controlled on specific geographic areas, or management units (Fig. 1), using three harvest strategies: harvest objective, limited entry, and a split-strategy. Under the **harvest objective strategy**, managers prescribe a quota, or number of cougars to be harvested on the unit. An unlimited number of licensed hunters are allowed to hunt during a season that is variable in length, as the hunting season closes as soon as the quota is filled or when the season end date is reached. Under the **limited-entry strategy**, harvests are managed by limiting the number of hunters on a unit. The number of hunters is determined based upon an expectation of hunting success and the desired harvest size. Individuals are usually selected for hunting on the unit through a random drawing process. Under the **split strategy**, units start the season as limited entry, and then transition to a harvest objective strategy after approximately 8 weeks using the number of limited-entry permits that remain unfilled at the time of the transition as the quota for the remaining weeks of the season.

In 1996 the Utah Wildlife Board approved a Predator Management Policy (UDWR 1996) that allows UDWR to increase cougar harvests on management units where big game populations are depressed, or where big game has recently been released to establish new populations. Most predator management plans directed at cougars have been designed to benefit mule deer (*Odocoileus hemionus*) and bighorn sheep (*Ovis canadensis*). Cougar harvests have been liberalized where big game populations are far below objective (<50% of target densities) under the assumption that large harvests will reduce cougar numbers and hence predation rates on big game, and therefore encourage growth of big game populations by improving survival. Because drought, habitat alteration and loss and predation have substantially reduced mule deer populations over significant portions of Utah in recent years, predator management plans remain



**Figure 1.** Wildlife Management Units used by Utah Division of Wildlife Resources to manage cougar harvests. Some of the units have been subdivided for additional control of harvests.

in effect on much of the State's cougar range. Currently predator management plans are in place on 26 of 48 cougar management units or subunits open to harvest.

In 1999, UDWR implemented a Nuisance Cougar Complaints policy (UDWR 1999a) to provide guidance for reducing damage to private property and reducing public safety concerns, and to provide direction to UDWR personnel responding to cougar depredation, nuisance, and human safety situations. Any cougar that preys upon livestock or pets or that poses a threat to human safety is euthanized, as are sick or injured adult cougars and kittens that are unable to care for themselves in the wild. The Division does not rehabilitate these animals. The only cougars that are captured and translocated are adults and subadults that wander into urban or suburban "no tolerance zones" in situations where they have not been aggressive toward humans, pets, or livestock.

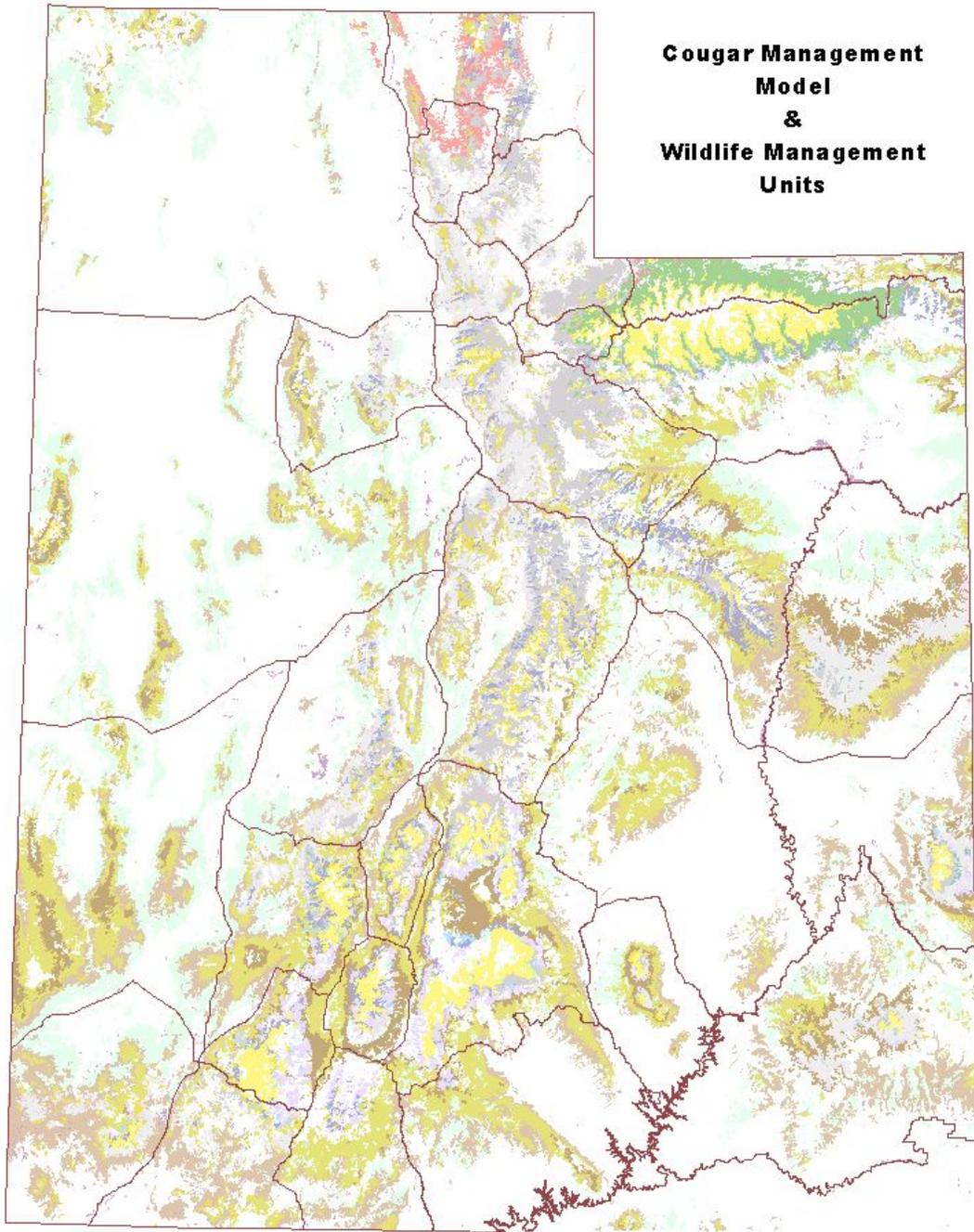
### **Distribution and Abundance**

Utah's cougar habitat encompasses about 92,696 km<sup>2</sup> (35,790 mi<sup>2</sup>; Fig. 2). Cougars are distributed throughout all available habitats within the state. Residential and commercial development is incrementally reducing cougar distribution through habitat alteration and destruction, particularly along the western border of the Wasatch Mountains in northern and central Utah.

The last statewide cougar population estimates were developed in conjunction with the Utah Cougar Management Plan in 1999 (UDWR 1999b). These estimates used extrapolations of cougar densities from published studies in the southwestern United States to: 1) the total area within all management units that comprise cougar range, and 2) the total amount of occupied cougar habitat within Utah. The habitat quality within each management unit was classified as either high, medium or low based on vegetative characteristics, terrain ruggedness (following Riley 1998) and prey density. Cougar densities derived from research within Utah, California and New Mexico were associated with each habitat quality level (UDWR 1999b). High quality habitat was assigned a density range of 2.5-3.9 cougars/100 km<sup>2</sup>, medium quality habitat was assigned a density of 1.7-2.5 cougars/100 km<sup>2</sup> and a density of 0.26-0.52 cougar/100 km<sup>2</sup> was assigned to low quality habitat.

The first statewide population estimate of 2,528-3,936 cougars resulted from summing unit population estimates. The number of cougars on each unit was estimated by first multiplying the total area contained within the unit by the highest density of the range assigned to it, and then by the lowest density of the range assigned to it.

For comparison, a second estimate of 2,927 cougars statewide was generated based upon mean cougar densities and total occupied cougar habitat within the state. Each management unit's cougar population was estimated by extrapolating the mean cougar density assigned to the unit (based on the respective range indicated above) to the amount of occupied cougar habitat within the unit, and unit estimates were summed to obtain the statewide figure. The two methods produced population estimates that show considerable agreement, but they should be only viewed as general approximations of the statewide cougar population.



**Figure 2.** Cougar habitat in Utah. All colored areas represent occupied cougar habitat.

Utah's cougar population is monitored through mandatory reporting of all hunter-harvested cougars, cougars that are killed on highways or in accidents and those taken by animal damage control programs (Table 1). Location of kill, sex and age (through a premolar for age estimation) are recorded for every cougar killed, and provide the data used to assess management performance in relation to established target values that serve as indicators of population status. "Rules of thumb", expressed as threshold values of: 1) A minimum percentage of older aged animals in the harvest, 2) A maximum percentage of females in the harvest, and 3) Minimum adult survival were set to ensure that cougar densities are maintained within all management units, except where predator management plans are in place. Threshold values of the harvest criteria were obtained from the literature and from past evaluations of cougar population dynamics in Utah. This approach is likely conservative, but it is justified based upon our limited knowledge of the abundance of deer and alternate prey in Utah (UDWR 1999b). Ongoing research on 2 study sites, under the direction of Dr. Michael Wolfe (Utah State University, See papers by Choate et al. 2006, Stoner et al. 2006, 2007), is supplying comparative data on the dynamics of cougars subjected to varying levels of hunting harvest. This information should help the Division refine management criteria in the near future. The Division also monitors trends in numbers of cougar incident reports, which have fluctuated in recent years (Table 2). Attempts to reduce the number of cougar management units that are subject to predator management plans have met with little success, mostly due to continued drought and deteriorating range conditions.

### **Harvest Information**

Cougar hunting in Utah is regulated on a management-unit basis to address differences in cougar densities, hunter access and management objectives. Annually, the composition of each unit's harvest is compared to performance targets that were selected to maintain cougar densities: 1) maintain an average of 15% or greater of the harvest in older age classes ( $\geq 6$  years of age); 2) maintain total adult survival at or above 65%; 3) restrict the female component to  $< 40\%$  of the harvest. In addition, an average treeing rate (rate of successful treeing/cornering a cougar) of 0.38 cougar/hunter/day is used as a reasonable expectation of success given viable cougar densities. Harvest prescriptions are elevated and the above criteria do not apply on any management unit that has a predator management plan in effect. In these units, the management objective is to reduce cougar numbers.

The harvest-objective strategy is often used on units where managers want to ensure a substantial harvest. This strategy can result in hunter crowding and less hunter selectivity toward males, as many hunters take the first cougar they encounter. Consequently, the harvest may be weighted toward young animals and females.

Conversely, limited-entry hunts allow managers to spread hunting effort over a longer time-period and shift harvesting pressure toward adult males. This strategy is commonly used on management units that are readily accessible to hunters to minimize crowding and promote hunter selectivity for adult males.

Since 2001, a few units have been harvested under a hybrid strategy, where both harvest-objective and limited-entry hunts are held. This approach attempts to produce a large harvest

**Table 1.** Utah cougar harvests, 1989-90 through 2006-07.

Season Year	Hunters afield	Limited entry permits	Harvest objective permits	Sport Harvest males	Sport Harvest females	Total sport harvest	Mean age	Percent permits filled	Percent quota filled	Percent females	Percent USDA APHIS/WS harvest	Other mortality	Total mortality	Adult survival rate	Percent > 6 yrs old	Treed per pursuit day
1989-90	478	527		146	71	217		41.2%		32.7%	48	10	275			0.41
1990-91	480	525		184	81	265		50.5%		30.6%	38	22	325			0.49
1991-92	485	525		160	81	241		45.9%		33.6%	34	22	297			0.45
1992-93	538	591		260	112	372		62.9%		30.1%	53	42	467			0.49
1993-94	575	659		216	136	352		53.4%		38.6%	53	10	415			0.57
1994-95	656	791		262	169	431		54.5%		39.2%	54	24	509			
1995-96	787	872		269	183	452	3.5	51.8%		40.5%	33	39	524	67%	16.7%	0.48
1996-97	1,376	595	275	297	279	576	3.8	56.0%	88.3%	48.4%	40	50	666	67%	20.0%	0.33
1997-98	1,109	509	270	261	231	492	3.2	54.4%	79.6%	47.0%	27	23	542	63%	14.5%	0.36
1998-99	939	446	230	206	167	373	3.1	49.0%	64.0%	44.8%	13	1	387	62%	10.1%	0.30
1999-00	817	343	304	258	177	435	2.9	60.0%	81.0%	40.7%	25	9	469	60%	9.7%	0.28
2000-01	1,341	272	371	242	207	449	3.3	52.0%	35.4%	46.1%	27	20	496	63%	12.8%	0.30
2001-02	1,353	266	339	222	184	406	3.1	57.9%	74.3%	45.3%	45	17	468	61%	11.5%	0.21
2002-03	1,231	374	297	251	175	427	3.6	58.3%	77.1%	41.0%	53	30	510	63%	13.3%	0.29
2003-04	936	266	492	219	229	448	3.4	55.2%	66.3%	51.1%	47	28	523	61%	13.8%	0.23
2004-05	1,309	276	527	190	131	321	2.5	45.3%	36.2%	40.8%	38	21	380	54%	6.5%	0.17
2005-06	1,016	406	227	202	137	339	3.2	58.6%	44.5%	40.4%	35	15	389	62%	8.9%	0.19
2006-07	1,126	366	185	173	117	291	2.9	58.5%	41.6%	40.2%	9	25	325	63%	10.5%	0.22
Total	16,552	8,609	3,517	4,018	2,867	6,887					672	408	7,967			
Mean	920	478	320	223	159	383	3.2	53.6%	62.6%	41.6%	37	23	443	62%	12.4%	0.34
Performance targets:										40.0%				65%	15.0%	0.38

**Table 2.** Confirmed livestock losses due to cougar depredation in Utah, FY1993 (1992-93) to FY2007 (2006-07).

Fiscal Year	Number of Incidents	Confirmed Losses:						Total Confirmed Losses	Value Losses	Cougar taken by USDA/APHIS
		Ewes	Lambs	Bucks	Calf	Goat	Other			
1993	114	263	722	1	2	0	0	988	\$94,644.00	53
1994	115	258	646	5	6	0	0	915	\$120,615.00	53
1995	152	335	760	24	12	0	0	1,130	\$111,495.00	54
1996	112	257	621	2	6	0	0	878	\$79,277.00	33
1997	110	375	531	20	11	0	0	937	\$106,210.00	46
1998	114	253	506	19	13	0	0	805	\$97,703.00	27
1999	69	244	406	18	4	0	0	730	\$92,945.00	11
2000	82	160	371	2	15	0	0	548	\$60,750.00	22
2001	74	136	361	12	3	1	0	587	\$61,395.00	18
2002	95	167	453	18	11	2	1	652	\$70,351.34	74
2003	108	204	778	8	4	22	3	1,127	\$81,067.00	33
2004	89	222	533	7	9	5	0	776	\$108,917.25	38
2005	69	99	362	2	1	19	0	483	\$64,911.61	27
2006	50	56	228	0	32	26	0	342	\$77,415.00	13
2007	42	46	265	0	0	7	0	318	\$43,082.50	18
<b>Total</b>	<b>1,395</b>	<b>3,075</b>	<b>7,543</b>	<b>138</b>	<b>129</b>	<b>82</b>	<b>4</b>	<b>11,216</b>	<b>\$1,270,778.70</b>	<b>520</b>

while encouraging some hunter selectivity. Under the hybrid strategy, a limited-entry hunt is opened early, followed by a harvest-objective hunt that is delayed until mid-winter. In the past, managers have used female sub-quotas in conjunction with harvest-objective strategies to protect females in the face of increased harvest pressure. This strategy has been discontinued because it biased the harvest sex composition toward females (through early closure when the sub-quota was attained) and prevented meaningful evaluations of harvest sex composition under criterion 3 above.

Each year, regional wildlife managers review the size and composition of harvests from individual units in relation to management rules of thumb and then make recommendations for the forthcoming season. Often, their evaluations result in changes in the number of permits allocated the size of quotas and/or changes in harvest strategy. These regulation changes often result in year-to-year fluctuation in harvest strategy and hence harvest pressure. As a result, variances in harvest size and composition are difficult to interpret. Total harvest has varied between 325 and 542 since the 1997-1998 season, with no definite trend (Table 1).

Nearly all cougars harvested in Utah are taken with the aid of dogs. An individual hunter is restricted to holding either a limited-entry permit or a harvest-objective permit per season, and must wait 3 years to reapply once he/she acquires a permit. The bag limit is 1 cougar per season and kittens and females accompanied by young are protected from harvest. Currently the cougar-hunting season runs from 21 November, 2007 through 1 June, 2008 on both limited-entry and harvest-objective units. However, some units are open year-round and some have earlier or later opening dates. Because harvest-objective units close as soon as the objective (quota) is reached, hunters must call a toll-free number daily to ensure that the season in their hunt unit is still open.

Pursuit (chase or no-kill) seasons provide additional recreational opportunities over most of the State. The pursuit season generally runs 21 November, 2007 through 1 June, 2008, but specific units have year-round pursuit and a few units are closed to pursuit hunting. In recent years, the Division has sold about 700-800 cougar pursuit permits annually (Table 3).

The Division began managing cougar harvests through statewide limited-entry hunting in 1990 and increased numbers of permits through 1995-1996 (Table 3). In 1996-1997, additional harvest pressure was added by switching some management units to the harvest-objective (quota) system and a record high of 1,376 hunters was afield (Table 1).

Units with predator management plans designed to reduce cougar densities produce harvests of similar composition to areas where the management objective is to sustain higher population densities (Table 4). Throughout the State, the proportion of harvest comprised of females has usually been above the prescribed threshold for maintaining cougar densities, the percent of older aged cougars in the harvest has remained below the desired threshold level, adult survival is below the desired level, and the cougar treeing rate is below the value ascribed as an indicator of secure population abundance. Given the relative abundance of *de facto* refugia for cougars in Utah (National Parks, wilderness and inaccessible tracts) and the species' propensity to disperse long distances, current harvest prescriptions may not prove effective for attaining either of the

**Table 3.** Number of cougar pursuit permits sold in Utah, 1989-90 through 2006-07.

Year	Limited-Entry Permits			Total	Harvest-Objective Permits			Total Permits	Pursuit Permits
	Resident	Nonresident	Conservation		Resident	Nonresident	Total		
1989-90	385	142		527				527	355
1990-91	383	142		525				525	364
1991-92	383	142		525				525	524
1992-93	431	160		591				591	570
1993-94	479	180		659				659	552
1994-95	559	232		791				791	505
1995-96	611	261		872				872	627
1996-97	425	170		595	n/a	n/a	901	1,496	638
1997-98	381	128		509	472	199	671	1,180	635
1998-99	337	109		446	386	189	575	1,021	630
1999-00	259	84		343	374	170	544	887	545
2000-01	206	66		272	880	290	1,170	1,442	692
2001-02	228	30	8	266	897	300	1,197	1,463	681
2002-03	326	36	12	374	685	266	951	1,325	703
2003-04	215	29	20	264	533	209	742	1,006	772
2004-05	233	30	10	273	841	290	1,131	1,404	703
2005-06	356	38	12	406	464	222	686	1,092	730
2006-07	313	35	18	366	600	245	845	1,211	714
Total	6,510	2,014	80	8,604	6,132	2,380	9,413	18,017	10,940
Mean	362	112	13	478	613	238	856	1,001	608

**Table 4.** Comparison of harvest characteristics for Utah management units that have predator management plans (designed to reduce cougar numbers) and units that are managed to sustain cougar populations.

Criteria (threshold for sustaining population)	Predator Management Plan in Place			No Predator Management Plan		
	1999-00	2000-01	2001-02	1999-00	2000-01	2001-02
% Females (<40)	45	45	41	38	46	47
% > 6 years (>15)	9.7	9.8	10	7.6	12.3	9
Adult Survival (>0.65)	0.60	0.61	0.52	0.59	0.61	0.62
Cougar treed/day (0.38)	0.24		0.16	0.30		0.24

State's management objectives (maintenance of population density, or substantial reduction in population density).

### **Evaluation of harvest information**

The harvest-based criteria used in Utah's cougar management system are based upon published research, and represent the expectation of harvest statistics that are associated with sustained population densities. However, managers have not been able to fully meet all threshold values since the Cougar Management Plan was adopted in 1999. There may be several explanations for this difficulty, including the geographic scale of management actions and differences in the vital rates of cougar populations within Utah.

The proportion of mature ( $\geq 6$  years of age) cougars in the harvest is used as an index of the presence of mature cougars in the underlying population. If this proportion declines below 15%, the management plan assumes that the harvest rate is unsustainable. However, scarcity of older-aged cougars in harvests could also result from light (sustainable) harvesting of a productive cougar population by nonselective hunters, where relatively few cougars are taken and the harvest is composed of mostly subadults and younger-aged adults.

The proportion of adult females in the harvest is assumed to increase with increasing harvest pressure, and the threshold level chosen for sustainability in Utah ( $>40\%$ ) is based upon research from several western states. However, managers are evaluating small management units, some containing  $<1,000 \text{ km}^2$  of cougar habitat. Populations on 8 of these units are estimated at  $<50$  cougars and they produce harvests of only a few animals. Consequently, individual animals comprise a large proportion of the unit's harvest (i.e., 1 cougar comprises 25% of a 4-cougar harvest). The addition or subtraction of 1 female can shift harvest percentages considerably, with consequent changes in management recommendations that may or may not be biologically significant.

The threshold adult survival value (0.65 survival overall) used by the cougar management plan is the only management criterion in use that relies on a direct measure of a vital rate. This information is based upon cementum age estimates, and is evaluated at a regional scale (groups of management units) or at the statewide level, where sample sizes are sufficiently large enough to remove individual-animal bias. The 0.65 survival threshold also assumes average reproduction and recruitment of cougars in Utah, as reported in the literature. Unfortunately, there is no current data on cougar productivity being collected within the State.

Utah's cougar management program suffers from the lack of current estimates of reproduction and juvenile survival. These vital rates may vary considerably in response to changing prey abundance and as social structure is impacted by harvesting. Reproduction and juvenile survival could substantially influence a cougar population's ability to sustain harvest. Consequently, the Division should develop a means to monitor both reproduction and juvenile survival.

### **Future needs**

The Division needs greater understanding of the underlying assumptions of the management criteria adopted by the Cougar Management Plan and of cougar population dynamics within

Utah. We also need to determine the appropriate geographic scale for managing cougars and to resist the temptation to adjust harvest regulations annually. Currently, management is operating on an individual-unit scale, where interpretation of harvest data is hampered by small sample sizes. Attempts to evaluate harvests on larger geographic scales or multi-year time frames are confounded by the continual change in regulations and harvest effort on individual management units.

In the future, research and management should focus on obtaining and applying reliable indicators of cougar productivity and survival, and ultimately population growth. Specifically, our harvest management efforts should improve with understanding of cougar movements and dispersal, particularly between lightly hunted and heavily harvested cougar populations. In addition, we need greater confidence in our ability to evaluate a population's ability to sustain harvesting, and better measures of population growth.

### **Depredations and Human Interactions/Conflicts**

Under Division policy, cougars that prey upon livestock or pets or cause public safety concerns are lethally controlled (UDWR 1999a). The number of cougars killed due to these conflicts has fluctuated markedly in the past 5 years, from a high of 53 in 2002-2003 to a low of 9 cougars in 2006-2007 (Table 1). USDA APHIS, Wildlife Services handles most livestock depredation complaints under a memorandum of understanding with UDWR. Their reports are compiled on a fiscal year basis (and therefore numbers/year differ from those reported in Table 1), and confirm livestock losses ranging from \$43,000 to \$109,000 per year since 1998 (Table 2). Cougars were implicated in 42-114 separate depredation incidents per year during this period, killing 318-1,127 sheep, cattle and goats annually (Table 2).

### **Research and Publications**

UDWR is funding research conducted through the Utah State University, under the direction of Dr. Michael Wolfe. This research has been ongoing on two study sites since 1995, and is directed at determining means of quantifying cougar populations and evaluating the effects of harvesting on them. Field research is currently underway by David Stoner, PhD candidate.

### **Recent publications**

- Bernales, H. H., K. R. Hersey, and K. Bunnell. 2008. Utah cougar annual report 2006 and 2007. Annual performance report, Fed. Aid Project No. W-65-M-54 and 55. Publication Number 08-35, Utah Div. Wildlife Res., Salt Lake City. USA, 75 pp.
- Choate, D. M., M.L. Wolfe, and D.C. Stoner. 2006. Evaluation of cougar population estimators in Utah. *Wildlife Society Bulletin* 34(3): 782-799.
- Hill, H. and K. Bunnell. 2005. Utah cougar harvest report 2001-2002 to 2004-2005. Annual performance report, Fed. Aid Project No. W-65-M-50, 51, 52 and 53. Publication Number 05-39, Utah Div. Wildlife Res., Salt Lake City. USA, 65 pp.
- Stoner, D. C., M.L. Wolfe and D.M. Choate. 2006. Cougar exploitation levels in Utah: Implications for demographic structure, population recovery, and metapopulation dynamics. *Journal of Wildlife Management* 70(6): 1588-1600

Stoner, D. C., W. Reith, M.L. Wolfe, and A. Neville. 2007. Long-distance dispersal of a female cougar in and range landscape. *Journal of Wildlife Management* 72(4): 933-939.

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Riley, S. J. 1998. Integration of environmental, biological, and human dimensions for management of mountain lions (*Puma concolor*) in Montana. Ph. D. Dissertation, Cornell University, Ithica, NY, USA 158 pp.

UDWR. 1996. Predator Management Policy. Utah Division of Wildlife Resources, Salt Lake City. USA

UDWR. 1999a. Nuisance Cougar Complaints. Policy No. W5WLD-5. Utah Division of Wildlife Resources, USA 4 pp.

UDWR. 1999b. Utah Cougar Management Plan. Utah Division of Wildlife Res. Salt Lake City. USA, 60 pp.

## Colorado Mountain Lion Status Report

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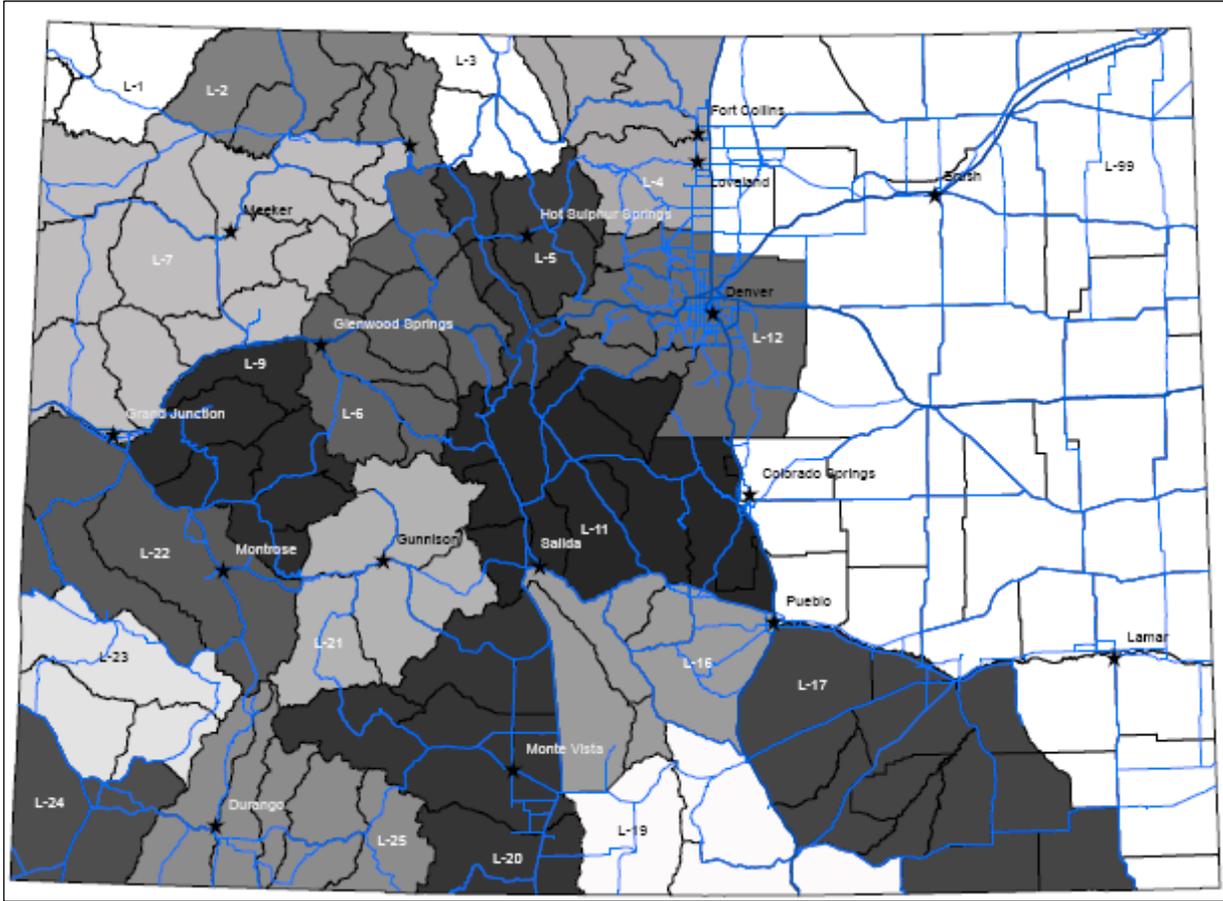
### Management Background

Mountain lion (*Puma concolor*) received no legal protection and were classified as a predator in Colorado from 1881 until 1965. During these years the take of mountain lion at any time, any place was encouraged by bounties and other laws. The bounty was abolished in 1965, but some provision for landowner take of a depredating lion remains in Colorado laws to this day. In 1965, mountain lion were reclassified as big game. In 1996 the Colorado Department of Agriculture (CDA) was granted “exclusive jurisdiction over the control of depredating animals that pose a threat to an agricultural product or resource.” Thus, CDA has exclusive authority to determine the disposition of an individual lion if it is depredating on livestock, while the Colorado Division of Wildlife (CDOW) retains authority to manage lion populations, all forms of recreational or scientific use, and resolution of human-lion conflicts.

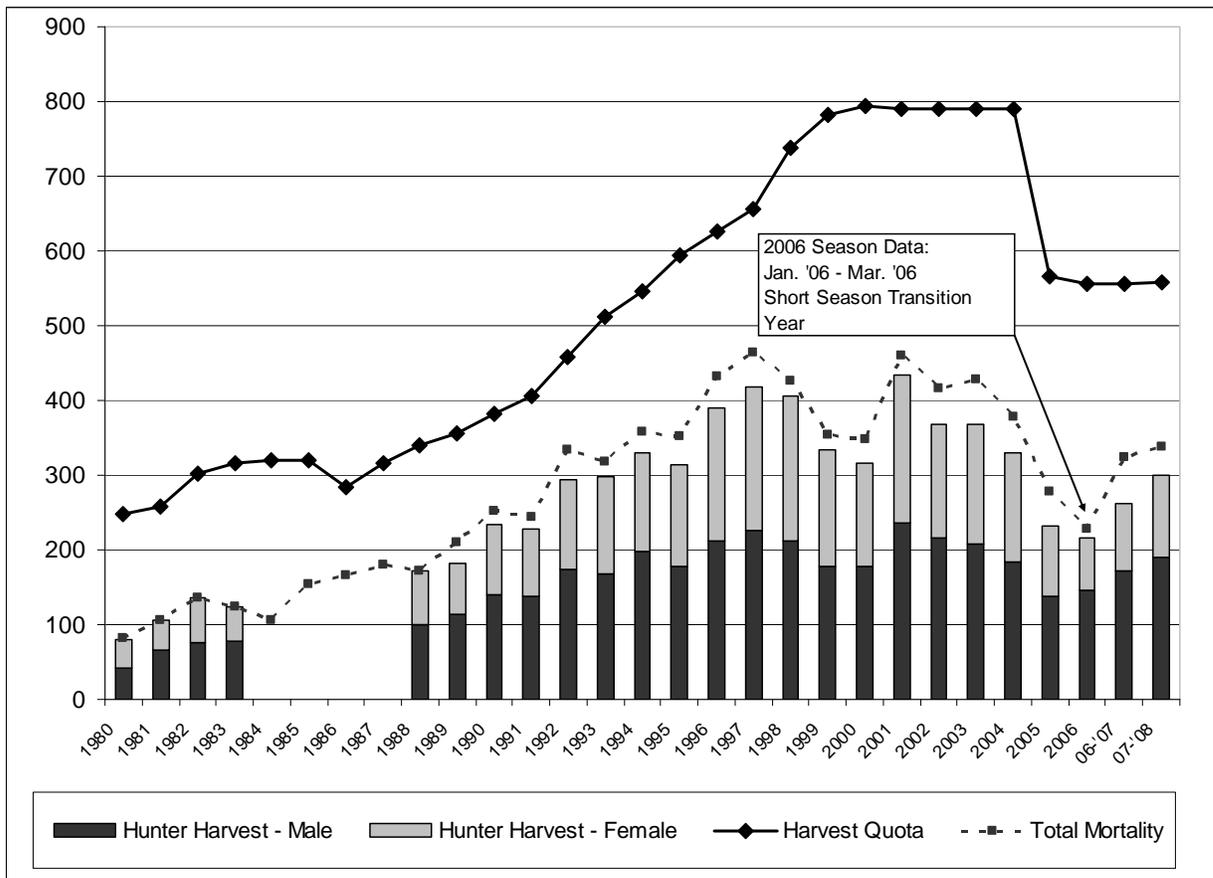
The State is divided into 19 Data Analysis Units (DAUs) for the purpose of lion management (Fig. 1). DAUs are assemblages of Game Management Units (GMUs). Since 1972, Colorado sets harvest limit quotas for one or more GMUs within DAUs for the purpose of limiting and distributing harvest. Hunters are allowed to take one lion per season of either sex. Colorado does not currently use female harvest limit sub-quotas.

Hunter harvest, non-hunter mortality, game damage conflicts, and human-lion conflicts are monitored annually within DAUs for crude indications of population change. Lion mortality is documented through mandatory checks of hunter kill and mandatory reports for non-hunter mortality and is kept in a database. The database for hunter kill has been kept since 1980 and for non-hunter mortality since 1991. Data on depredation claims since 1979 is also maintained in a database, although the data from 1979-1987 is somewhat suspect due to inconsistent reporting and record keeping.

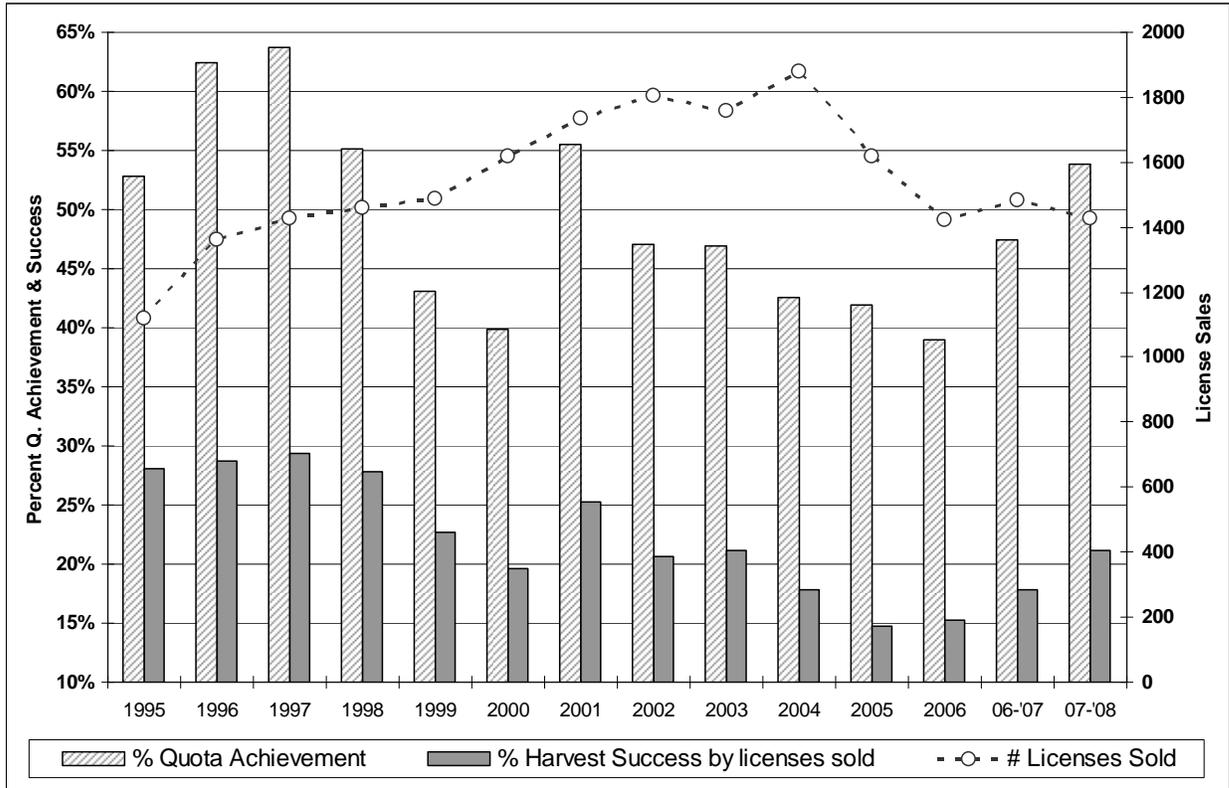
Lion harvest limit quotas increased from 1980 to 1999, leveled out until 2005 when a substantial reduction was enacted, and have been held at about 2005 levels since (Fig. 2). Hunter harvest gradually increased from 1980 to 1997, showed some variability in 1998 to 2004, and declined from the prior 5-year average during 2005 through 2007 (Fig. 2). The 2007 figures are projections based on preliminary harvest and non-harvest data. Variation in 1998-2004 harvest appeared mostly attributed to snow hunting conditions, local public and private land access issues. Reduced harvest levels in 2005-2007 are attributed mainly to efforts to reduce the take of females but are also aligned with the reduction to harvest limit quotas. See further discussion on this in the “New Efforts” section of this report. License sales are recorded as an indicator of hunter participation and hunter success is derived by dividing license sales into harvest (Fig. 3). The level of quota achievement has been used as a surrogate for hunter success on a localized basis



**Figure 1.** Colorado mountain lion Data Analysis Units (DAUs).



**Figure 2.** Colorado mountain lion harvest limit quota, harvest, total mortality 1980 – 2007/2008. Data for 2007/2008 is a projection based on preliminary information.



**Figure 3.** Colorado mountain lion license sales, success, quota achievement 1995 – 2007/2008. Data for 2007/2008 is a projection based on preliminary information.

when quotas have remained static or have only gradually been adjusted. The utility of this as a surrogate for hunter success, however, becomes suspect if there are significant or frequent changes to the quota.

The 2005 harvest limit quota reduction stemmed from analysis which occurred during revision of DAU plans in 2004. In some cases harvest limit quota reductions were intended to produce a slight reduction in lion harvest, but in most cases reductions were intended to have a negligible harvest affect but realign the harvest limit quota closer to the harvest objective. In most DAUs the harvest limit quota is somewhat higher than the harvest objective due to a DAU history in which the objective is rarely or never achieved. Yet in these DAUs, harvest limit quota represents the upper limit on harvest that managers believe could be endured for a one or two year period. The caveat being that if mortality did not drop to within harvest and mortality objectives in a two year period, then harvest limit quota reductions would be the likely response.

### **New Efforts Since 2005**

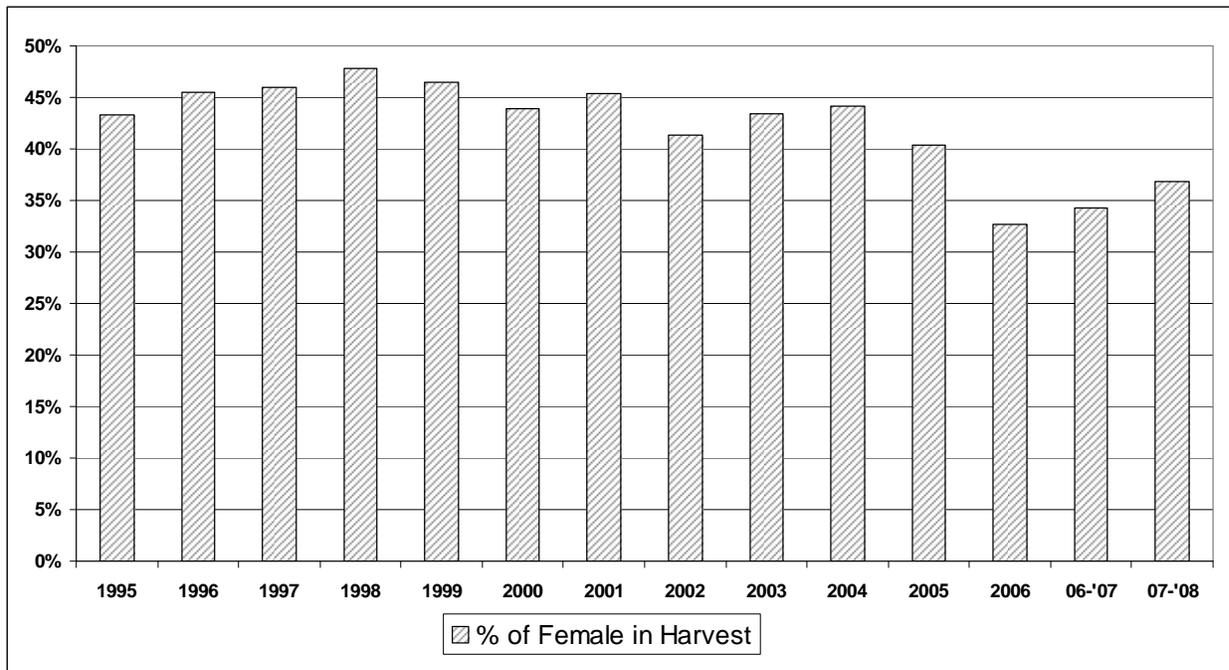
Since the Colorado status report provided at the May 2005, 8<sup>th</sup> Mountain Lion Workshop an update on new or ongoing initiatives includes: voluntary efforts to reduce female component in hunter harvest, Uncompahgre research project will enter a new phase, human-lion interaction research, mountain lion genotype testing, and telomere aging applications research. Following is a brief discussion of each of these efforts.

**Female Harvest Component:** During the summer of 2005, CDOW and the United Houndsmen of Colorado conducted and co-sponsored a series of workshops across the State. These workshops provided information about the biology and life history of mountain lion as well as the importance of females. Our effort was intended to spread the word within the lion hunting community about our request for hunters to voluntarily refrain from the take of females in most DAUs in Colorado. This was followed up with information published in our hunting brochure along the same line, but more specifically identifying the DAUs in which the reduction in female harvest was aimed.

Consequently, there was a slight drop in the proportion of females in hunter harvest from about 44% on average during the prior 5 years to about 40% in 2005 (note that the information and request came during the summer break in 2005 lion hunting season). There was a more significant decline in the 2006 and 2006/2007 lion seasons to about 34% female component of hunter harvest (Fig. 4). For 2007/2008 lion seasons, at the direction of our Wildlife Commission, CDOW implemented a mandatory mountain lion hunter education requirement. The course provides training information to hunters about mountain lion ecology and hunters must pass an exam demonstrating ability to identify lion gender characteristics.

During 2005 through 2007/2008 seasons hunter harvest declined, apparently as an unintended consequence of hunter efforts to reduce female harvest (Fig 2). Hunters that passed on taking a female lion likely did not have a subsequent opportunity to kill a lion during the time they had available for hunting. Therefore, preceding the 2007/2008 seasons CDOW communicated to lion hunters a change in criteria for selecting the DAUs

in which we request voluntary reduction in the take of females. As a consequence of this change we anticipated a slight increase hunter harvest and in the female component of harvest in 2007/2008. Based on preliminary information we project that the female component of hunter harvest during the 2007/2008 hunting season will rise to about 37% (Fig. 4).

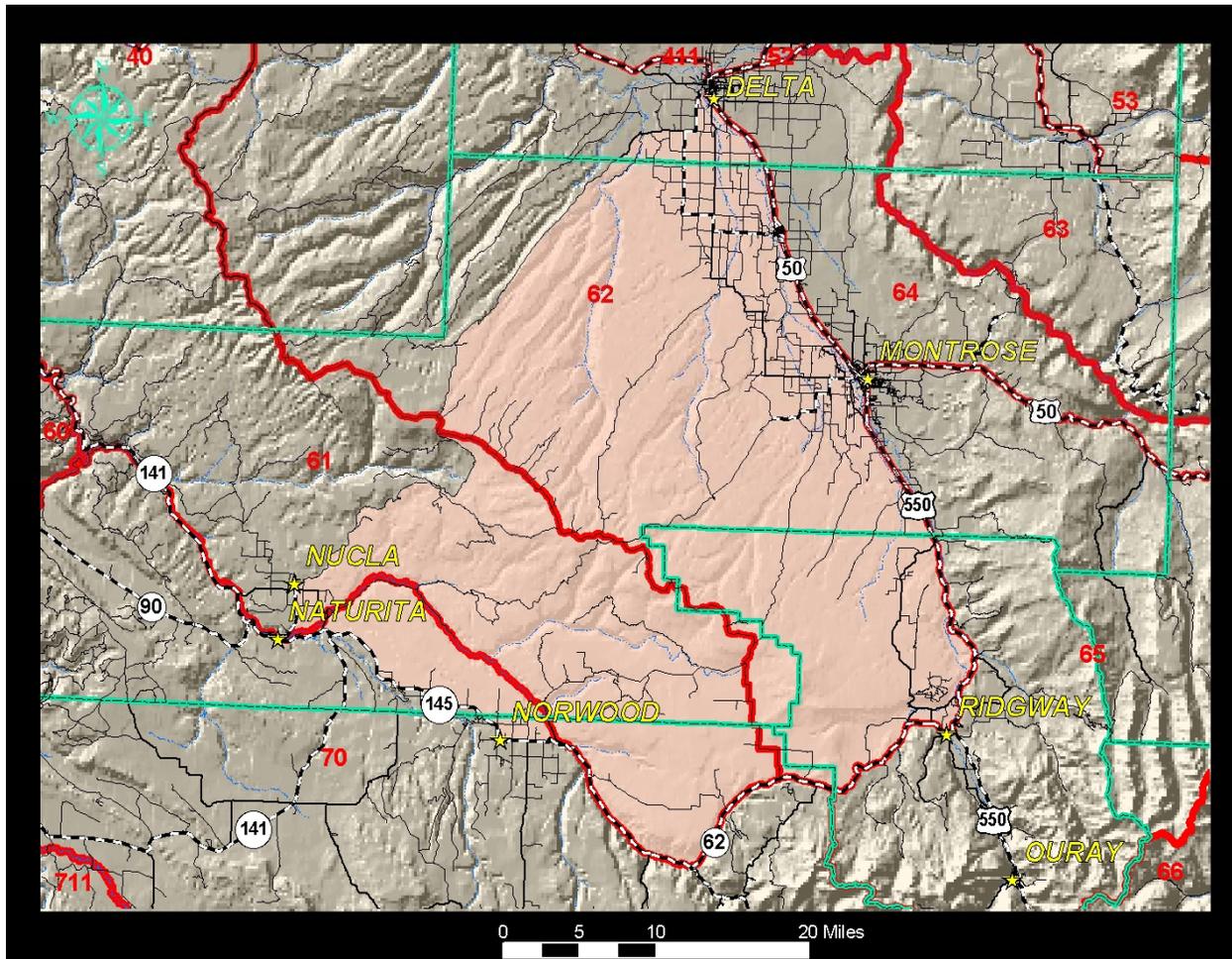


**Figure 4.** Percentage of females in hunter harvest 1995 – 2007/2008. Data for 2007/2008 is a projection based on preliminary information.

The management criteria we currently use for determining which DAUs will be highlighted for reduction in female take by hunters is: the 5-year average females in hunter harvest is > 35% of the DAU harvest objective; or the 5-year average females in total mortality is > 40% of the total mortality objective; and applies only in DAUs managed toward a stable or increasing mountain lion population.

Uncompahgre Plateau Research: An 870 mi<sup>2</sup> area on the southern end of the Uncompahgre Plateau in southwest Colorado was selected for a long-term research project (Fig. 5). The basic research design is an experimental manipulation of the lion population in two 5-year phases. Desired outcomes from this research include: estimation of population parameters and changes during a reference phase (no hunting to influence population dynamics) and a treatment phase (hunting manipulation of the population); identification of habitat preferences and linkages; lion-prey relationships; and testing current CDOW lion management assumptions. Plans are underway to develop and test methods to estimate lion abundance primarily using mark-recapture. Indices to lion abundance under consideration include change in harvest sex and age structure and aerial track surveys. This research is entering the fourth year and capture efforts to date have maintained about 20 adult lions/year marked with GPS collars. In the

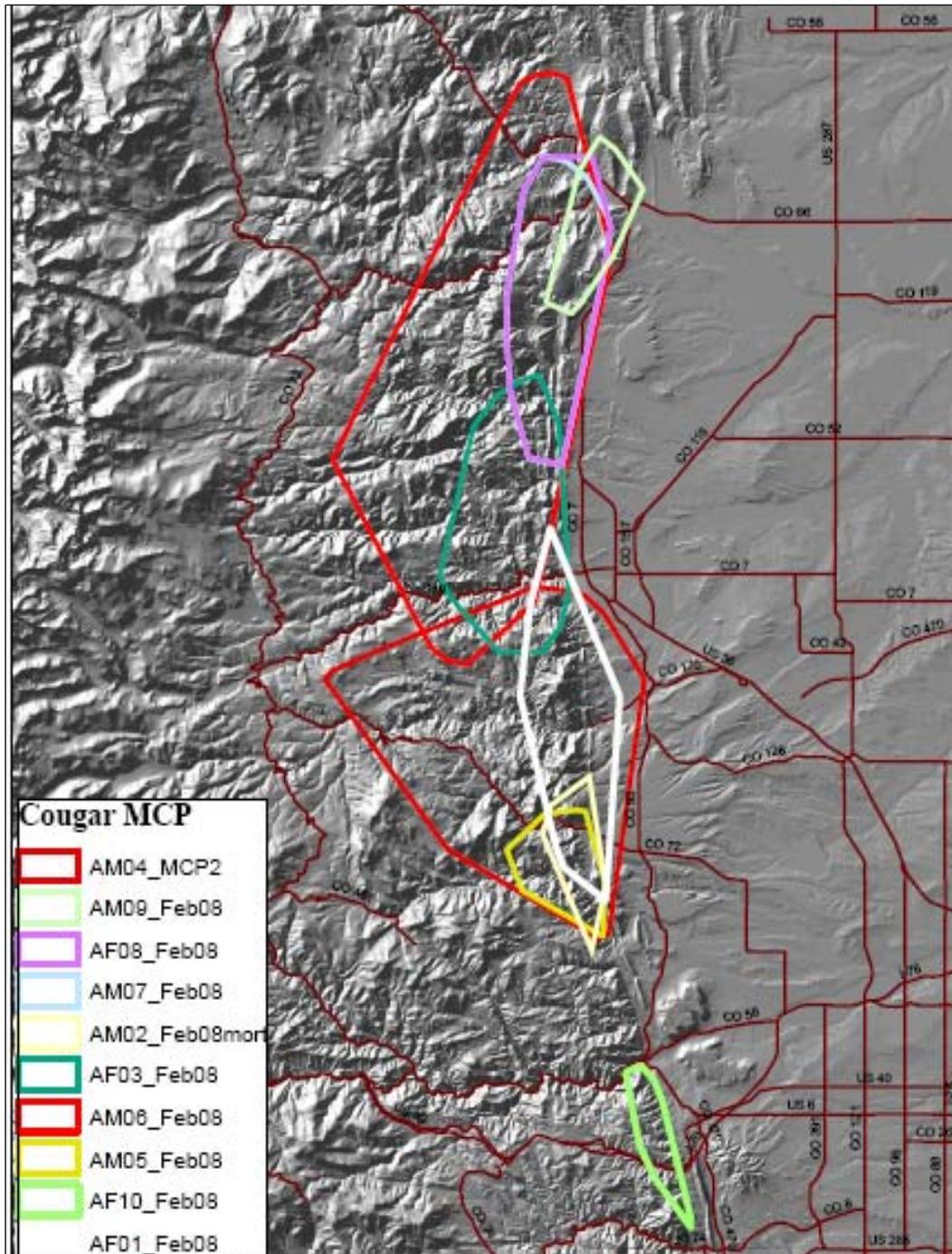
fall/winter of 2009 the treatment phase of the research will begin. Specific research protocols are being assessed, but manipulation of the lion population will primarily be accomplished using hunter harvest managed with harvest limit quotas to limit total and female off-take.



**Figure 5.** Location of the Uncompahgre Plateau mountain lion research project.

Front Range Research: Research began in 2007 with pilot efforts to test capture techniques and to develop aversive conditioning protocols in the urban-wildland interface. Currently 13 mountain lions are collared and monitored. Desired research outcomes include demographics on a lion population in a human altered environment, predator-prey relationships, testing aversive conditioning and relocation success (survival, return to capture locations, and recidivism), and testing similar population estimation and indices techniques as the Uncompahgre research. The study area is located in the western foothills of the greater Denver metropolitan area. Mountain lions have been caught and collared west of Boulder, Lyons, and Golden, Colorado (Fig. 6).

Figure 6 is preliminary information not analyzed in detail or validated but is intended to display the general location of the study effort.



**Figure 6.** Preliminary minimum convex polygon home area of mountain lions captured in 2007, Boulder and Jefferson counties, Colorado (MCPs are unvalidated). Some individuals have died after these were plotted.

Genotyping Tests: We are genotyping individual lions from teeth collected from harvested lions to examine population structure and are examining degradation rates of DNA from fecal samples to determine the efficacy of feces as a non-invasive method of population estimation. We are using samples taken from known individuals and related siblings from captive animals. Epithelial cells from fecal samples are exposed to environmental conditions and submitted for analysis in various states of degradation. The desired outcome of this effort is to test the reliability of DNA genotyping from a controlled setting in comparison to field settings.

Telomere Aging: We are testing the applicability of deriving lion population age structure from telomeres. Telomeres are short tandem repeated sequences of DNA found at the end of eukaryotic chromosomes that stabilize the ends of chromosomes. Telomeres shorten in length as the age of an individual increases. There is an apparent high degree of variation in the rate of shortening within species. Thus, telomere length may not be useful for aging an individual precisely, but with enough samples may provide utility for representing the age structure of a population, and also gender specific age structure within the population. The relative change in the slope of best fit regression lines of population age structure and the gender specific age structure may provide insights about changes to the population.

Our initial effort uses samples from known age individuals and samples from individuals for which age has been estimated from cementum annuli. DNA samples from these individuals will be analyzed for telomere length and similarity or divergence of age structure regression will be compared. We are also testing sample quality and amounts to determine if field collection techniques are adequate or need to be modified.

For background information, see: Nakagawa, S., N.J. Gemmel, and T. Burke. 2004. Measuring vertebrate telomeres: applications and limitations. *Molecular Biology*. 13: 2523-2533.

### **Future Mountain Lion Management Challenges**

In an unscientific poll; a handful of wildlife managers, some representatives of hunting organizations and a species advocacy group were asked to identify the top challenges facing lion management in the future. The two top challenges are: 1) Managing lions and public response management at the urban-wildland interface, and 2) Balancing divergent perspectives about lion management.

Lion Management at the Urban-Wildland Interface: This was the most commonly identified management challenge, but perspectives differed on why it was the greatest challenge. Three central aspects of concern were expressed: managing human social responses to conflicts, managing lion populations, and conserving/maintaining habitat and connectivity.

***Human social response aspects:*** As human populations grow and natural habitats are altered, concerns were expressed about the potential for increasing attacks on

humans, predation on pets, hobby stock, and predation on natural prey (mule deer) in/near residential areas. Concerns about the foregoing are mainly focused on dealing with human responses and reactions, including social and political reactions. The development of rational human-lion response protocols was considered highly important and that response protocols should have broad public/political support and informed consent.

***Lion population management aspects:*** In human altered environments hunting lions using traditional hunting methods is difficult, since land is broken into numerous small parcels with different owners; all of whom may have different acceptance or tolerance of hunting. Some suggest that hunting lions with hounds reinforces a level of avoidance of humans. Others suggest that hunting disrupts stability in lion populations and leads to a younger population structure; which can lead to greater human-lion conflicts, asserting that younger animals have a greater propensity for conflicts with people. Research data is limited and arguments tend to be based more on personal values than by fact. So a challenge facing managers in the future: should lion hunting (either by traditional methods or different methods) in the urban-wildland interface be encouraged?

***Habitat conservation and connectivity aspects:*** Wildlife management agencies have few tools to influence the expansion of human development and conserve natural landscapes, leading to loss of natural lion habitat. Conversely, natural areas in the urban-wildland interface and human residential landscapes often promote abundance of native and alternative prey species which, in some places can support lion populations. Lion populations in these areas might exist at higher densities than those found in other studied populations, considering densities of deer and elk in/near towns and an abundance of alternative prey species including dogs, cats, raccoons, hobby stock, etc. From a habitat connectivity perspective, examples of lion population isolation can be found in some parts of California. Protection of corridors for population connectivity is probably more cost effective now than it will be in the future. So some future challenges: Is Colorado headed toward a future in which lion populations will become significantly fragmented? If so, should connectivity corridors be identified and protected? Moreover, if we accept that some natural landscapes will remain in the urban-wildland interface and lions will likely exist in these landscapes, should mechanisms for managing mountain lions be built into conservation plans for these “natural areas”?

**Balancing Divergent Perspectives:** The public have diverse perspectives about lions and their management, and those perspectives tend to be polarized. In a 2005 Colorado survey, respondents that reported strong to moderate support for or strong to moderate opposition to “continued regulated hunting of mountain lions” were nearly equally split 34% and 33% respectively. When the question was posed in another way, “should mountain lion hunting be banned”, most respondents either strongly agreed (20%) or strongly disagreed (25%), or were not sure (19%). However, there were also many areas of considerable agreement about aesthetic, ecological, and existence values across widely divergent demographic strata. Based on our experience in Colorado:

Mountain lion hunters and hunting interest groups are concerned that environmental and species advocacy interest groups will increase efforts opposing or restricting mountain lion hunting. Hunting interests have a strong desire to improve lion management efforts, but are also concerned about losing a desired form of hunting recreation. This concern is magnified because of the history of some wildlife related ballot initiatives. They have expressed concerns that when CDOW consults with and represents other constituency perspectives that these actions may indicate a dilution of or ignorance toward their concerns and can cause them to question the legitimacy of management decisions.

Species advocacy groups are concerned that they have limited opportunity to influence wildlife management decisions. They tend to view decision making processes as strongly influenced by hunting interests and that the Wildlife Commission is structured to favor these interests. A survey following a past ballot initiative indicated that they felt largely disenfranchised from decision making processes and thus had little recourse but to seek ballot mechanisms to achieve a desired outcome. However, when they feel decision processes have adequately considered their concerns, the outcome holds more legitimacy, even if not fully supported.

So a future challenge is how to incorporate divergent perspectives in a meaningful way and maintain legitimacy of wildlife management decisions.

## Arizona Mountain Lion Status Report

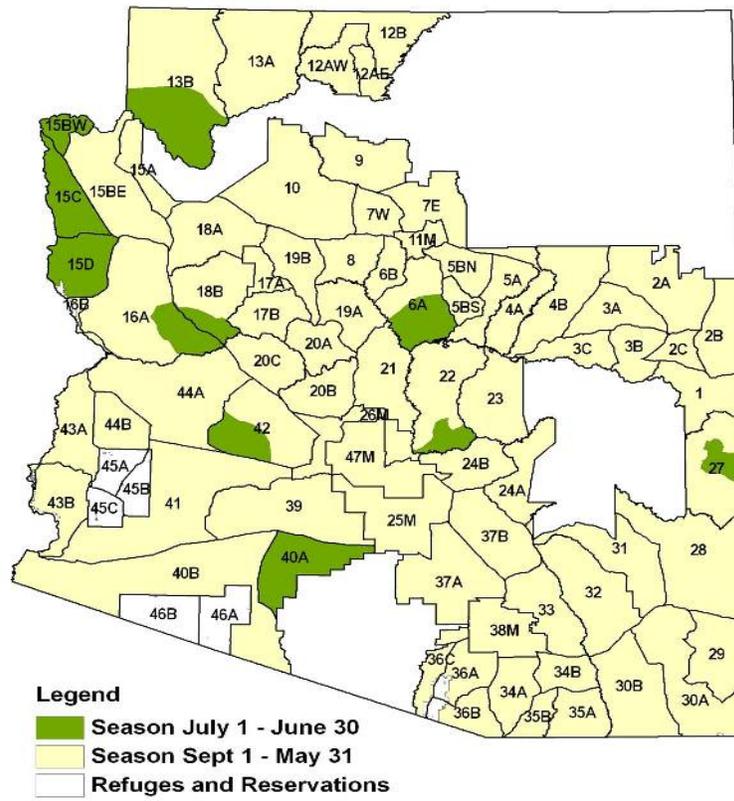
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### Background

Prior to 1970, the mountain lion (*Puma concolor*) in Arizona was classified as a predator and managed by the U. S. Bureau of Sport Fisheries and Wildlife, later the U.S. Fish and Wildlife Service. Bounties were paid for killing the state's second largest carnivore by the Arizona Livestock Sanitary Board (Housholder 1967). Starting in 1970, the Arizona Game and Fish Commission, appointed by the governor, became legislatively responsible for establishing hunting seasons, bag limits, and methods of take for the mountain lion as a big game animal. Between 1970 and 1989, a person could purchase a non-permit mountain lion tag from the Arizona Game and Fish Department (AZGFD) for just \$1.50 and hunt year-long statewide.

### Management Goal/Objectives

Arizona's current management goal is to manage the mountain lion population, its numbers and distribution, as an important part of Arizona's fauna and to provide mountain lion hunting recreation opportunity while maintaining existing occupied habitat and the present range of mountain lions in Arizona. Hunt management objectives are to provide hunting opportunity for  $\geq 6,000$  hunters during a 9-month general season from 1 September – 31 May and a harvest of  $\geq 250$  animals. In addition, Arizona has established hunt units with multiple bag limits that remain open year-long, or until the harvest quota is reached, and then the unit remains open or closed under the general hunt season period.



**Figure 1.** Multiple bag units for mountain lion in Arizona

Multiple bag units are evaluated for removal or addition annually on the basis of a recently translocated population of bighorn sheep, a declining population of deer or bighorn sheep or a bighorn sheep population below management objectives (Fig. 1).

### **Current Distribution and Adaptive Management**

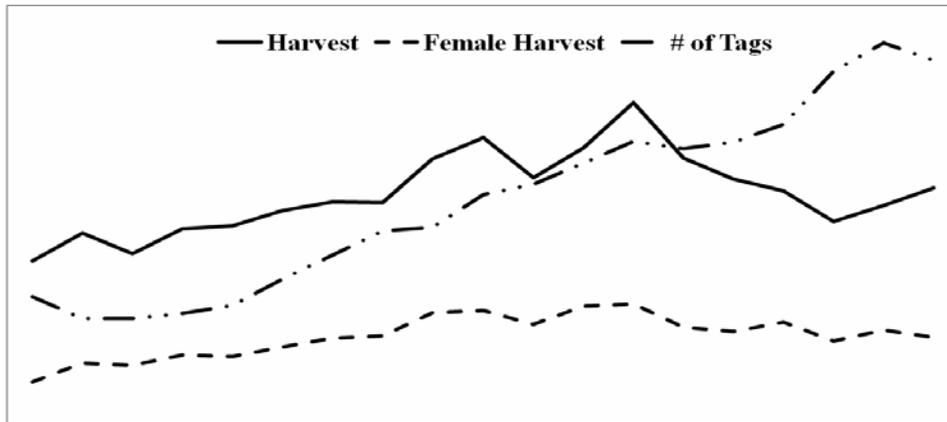
Mountain lion distribution in Arizona has recently been documented as increasing. Mountain lions now occupy even the harshest of environments along the western border of the state. Mountain lions now occur in the Kofa, Castle Dome, New Water, Palomas, and Eagle Tail Mountains, where no prior evidence of mountain lions was detected during surveys in 1987 (Shaw et al. 1988) or in 1996 (Germaine et al. 2000). The documentation of 5 different mountain lions (3 adults, 2 kittens) occupying the Kofa Mountains in 2006 sympatric with a declining extant population of desert bighorn sheep (*Ovis canadensis mexicana*), resulted in the implementation of an adaptive site-specific predator management plan directed at mountain lions known to be killing bighorn sheep at a rate of  $\geq 2$  animals during a 6-month period. During the past year, mountain lions ( $n=3$ ) were removed under this adaptive management strategy from the Kofa and Black Mountains.

## Hunt Regulations

Since the 8<sup>th</sup> Mountain Lion Workshop in 2005, Arizona has maintained a multiple bag limit quota for mountain lions in areas with translocated bighorn sheep populations or declining bighorn sheep and mule deer (*Odocoileus hemionus*) populations ( $n=9$ ) in an effort to increase hunter opportunity in specific areas. Additionally, new regulations have included: the implementation of a required carcass check-in by all successful mountain lion hunters for the collection of a tooth for aging and hair for DNA analysis; a reduction of the hunting season from 12 months to 9 months during the period September-May; all successful mountain lion hunters must now report their kill within 48 hours; female mountain lions with spotted kittens are protected; and livestock-depredating mountain lions may now be taken and possessed with a non-permit tag.

## Harvest

Arizona's past 5-year average sport harvest of mountain lions is 228, with a range of 204-251. Arizona's 36-year average sport harvest is 223, with a range of 120-326. During 2007, Arizona sold approximately 10,433 non-permit mountain lion tags, a decrease of 498 tags from 2006. In 2007, the first year of a mandatory carcass check-in, female mountain lions represented 42% ( $n=104$ ) of the total sport harvest ( $n=250$ ). The average number of females in the annual sport harvest over the past 20 year period was 104.



**Figure 2.** Arizona Mountain Lion Harvest Data for 1989-2007.

numbers due to recent drought conditions has reduced total livestock numbers in Arizona and may be partially responsible for reduced incidences of livestock depredation.

## Human/Mountain Lion Interactions

AZGFD has developed an action plan that guides employees in responding to human/mountain lion interactions. The plan was developed after extensive public input

and employee training and categorizes mountain lion behavior as either acceptable or unacceptable. Examples of acceptable behavior include:

**The animal retreats at the sight of a human.**

- The animal stays put while humans show no aggression.
- The animal shows signs of curiosity while humans show no aggression.
- The animal crouches, twitches its tail and stares directly into the person's eyes, immediately followed by retreating or showing no further aggression.

**While examples of unacceptable behavior include:**

- The animal displays unprovoked aggression.
- The animal exhibits forms of predatory behavior towards humans.
- Intentionally approaching close to a human after the animal knows the human has seen it, even if the human did not have to take evasive or aggressive action to drive the animal off.
- The animal continues to disturb, raid, or investigate humans or high-human-use areas.
- A lion that is seen in the vicinity of a school or other areas where children are congregated, especially during hours when children are present.
- A mountain lion that is not cornered but refuses to retreat when objects are thrown at it.
- A mountain lion spending > 1 day in a residential area (neighborhood yards) and is eating pet food or pets.
- The animal aggressively approaches a human, or fails to retreat when a human takes aggressive actions.
- Intentionally approaching a human at close range that requires the human to take some evasive or aggressive action to avoid attack.

The AZGFD maintains a statewide database for human-wildlife interactions. Responses of wildlife managers to mountain lion/human interactions are catalogued using a Mountain Lion Observation Form. Interactions are classified as; a sighting, encounter, incident or an attack. Since the inception of the database in late 2005, wildlife managers have responded to 405 reports involving mountain lions with 333 of these resulting in additional investigative actions such as a site visitation to verify the presence of a mountain lion and to better inform property owners of additional actions including possible removal of an animal exhibiting unacceptable behavior.

Although Arizona has yet to experience a mountain lion-caused human fatality, recently there was an attack on a 10-year-old boy by a rabid mountain lion resulting in minor injuries and numerous individuals exposed to rabies. During 2007, there was the unfortunate death of a biologist in Arizona due to a secondary plague exposure from a mountain lion that tested plague positive.

The AZGFD supports the Cooperative Wildlife Research Unit at the University of Arizona which is working on the establishment of a center whose primary objective will be to provide a full-service support unit to train and mentor students and biologists from around the world to conduct rigorous, focused, science-based studies of wild felids, including mountain lions.

## **Research**

Since the last mountain lion workshop, Dr. Ted McKinney, a researcher with AZGFD, and his associates, completed and published studies on mountain lion predation of translocated desert bighorn sheep in Arizona (McKinney et al. 2006a) and evaluation of factors potentially influencing a desert bighorn sheep population (McKinney et al. 2006b). The results can be found in a recent Wildlife Society monograph and bulletin.

Current studies are being conducted in support of an identified need to better understand how mountain lions are affected by the density of human development across the landscape. The concept that subpopulations of mountain lions are a part of a larger metapopulation (Sweaner et al. 2000) is supported in part by these on-going studies during which mountain lions utilized up to 5 different mountain ranges.

Arizona is expected to double in population by the year 2050 to approximately 12 million people. As human population growth continues, it will be accompanied by well-developed transportation systems that will affect mountain lion metapopulation dynamics, in ways not yet well understood. Arizona is also a border state that will have to monitor the impacts on large carnivores of the construction of a solid wall for miles along its border with Mexico. Arizona has a strong management interest in mountain lions and will be working towards the development of conservation strategies that will hopefully maintain the mountain lion as an integral part of its ecosystem for future generations to come.

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## South Dakota Mountain Lion Status Report

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**ABSTRACT** Mountain lions historically occurred in South Dakota but were nearly extirpated in the 1900s due to bounties and unregulated hunting on this animal from 1899 to 1966. Since receiving legal protection in 1978, the population has reestablished in the Black Hills of South Dakota. South Dakota Game, Fish and Parks (SDGF&P) has invested a large sum of money and time to conduct research on mountain lions to determine population size and distribution, evaluate population fitness, evaluate the effects of sport harvest, and assess genetic structure of lions and numerous other objectives. Based on this extensive research as well as other information SDGF&P collects, the Department offered a limited harvest on cougars in 2005 as well as 2006 and 2007. SDGF&P has collected data on lion mortality since 1996 with a total of 233 mortalities documented to date. SDGF&P began recording mountain lion reports in 1995 and continues to collect these data on a yearly basis.

## North Dakota Mountain Lion Status Report

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Mountain lions were native to North Dakota, although they were considered scarce in the open prairie country (Bailey 1926). According to historic records, in the 1800s, lions were documented in the North Dakota Badlands (Badlands), Killdeer Mountains, and along the Missouri River (MR). The species was not protected from indiscriminant killing, and by the early 1900s, the population was believed to be extirpated from the state (Young and Goldman 1946). In 1991, the mountain lion was classified as a furbearer with a closed season in North Dakota. Whether or not remnant individuals continued to breed in the Badlands, or lions migrated into North Dakota from other populations, or a combination of the two scenarios occurred, was unknown. Beginning in the late 1950s through the 1990s, the North Dakota Game and Fish Department (NDGFD) received sporadic reports of lions throughout the state, and continued presence of the animal in North Dakota became apparent during the early 2000s.

In 2005, the NDGFD assessed the status of mountain lions in North Dakota based on: 1) a review of verified sightings from 2001-2005; 2) a habitat suitability map created for the species; and 3) an experimental state-wide season with a quota of five animals. It was determined that the Badlands and associated MR Breaks region, including portions of Fort Berthold Reservation, had a sufficient amount of suitable habitat (approximately 4,637 km<sup>2</sup>) to support a relatively small population, and that the species had either re-established or was in the process of re-establishing itself in the Badlands (NDGFD 2006). Since 2005, mountain lions have been managed as a furbearer with a limited annual harvest, with provisions in place to remove nuisance animals for protection of property and human safety purposes. Lion presence continues to be documented in the Badlands, and based on verified reported sightings, including documentation of a family group on the Badlands/MR Breaks region border, the population may be expanding into the adjacent MR Breaks region (NDGFD 2007). Current management activities include: 1) documenting reported sightings of mountain lions; 2) surveying deer hunters and trappers for sighting information; 3) collecting biological information from mortalities; 4) conducting field surveys (e.g., snow track survey); 5) educating residents about lions; 6) responding to mountain lion/human/property conflicts; and 7) conducting research on mountain lions. The majority of management practices involve the participation of one or more cooperating agencies: (USDA Wildlife Services [WS], Theodore Roosevelt

National Park [TRNP], Three Affiliated Tribes [TAT], USDI Fish and Wildlife Service [FWS], and South Dakota State University [SDSU]).

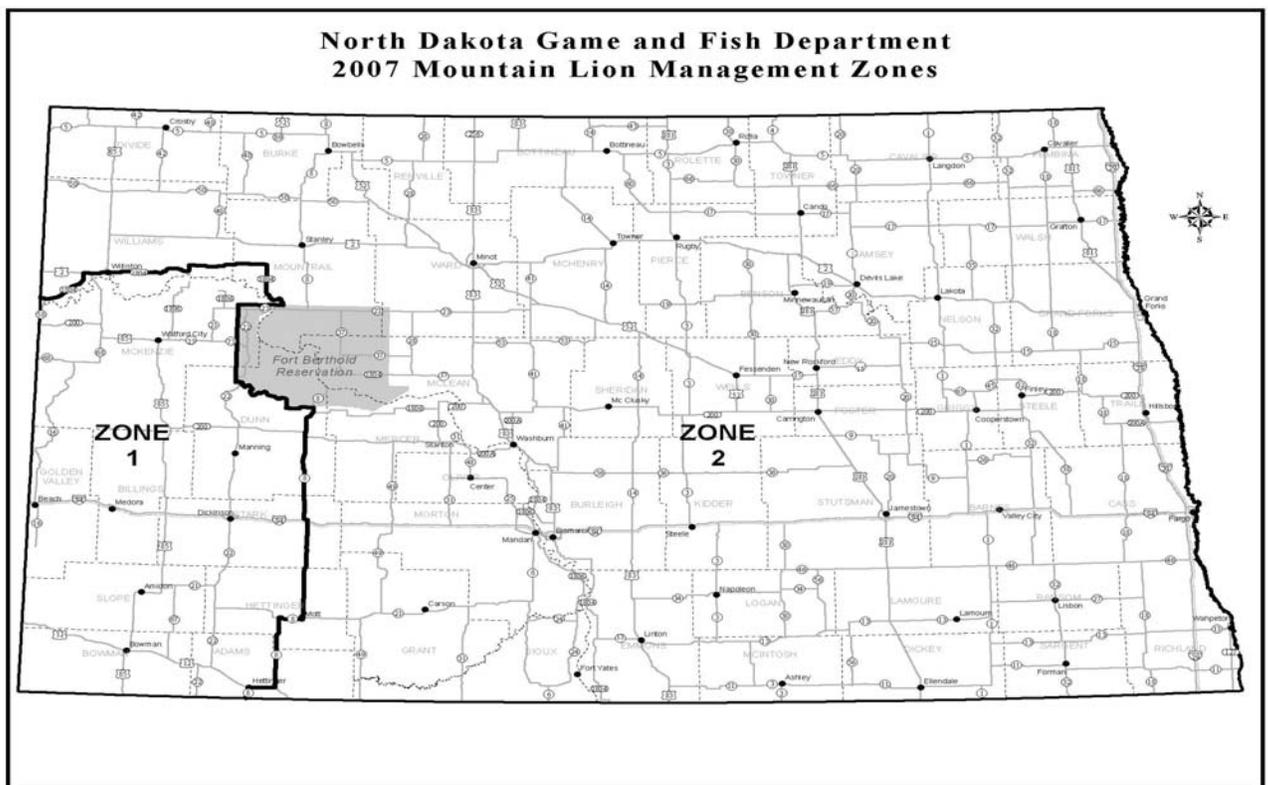
To understand the mountain lion population in North Dakota from a regional perspective, it was important to identify potential origins of these animals, assess the genetic health of the relatively isolated population in the Badlands, and determine likely migration routes among the Dakota states. Additionally, due to the large presence of ranching and agricultural operations in the Dakotas, it was appropriate to document the extent that domestic and livestock species occurred in diets of lions. Cooperative research between the NDGFD and SDSU was initiated to: 1) assess the genetic status of Dakota mountain lions; 2) create and test a habitat suitability map for lions in the Dakota states; and 3) Document food habits of mountain lions found in prairie and Badland landscapes. Additionally, in 2008, a cooperative research project between the NDGFD and TRNP was initiated to begin to collect additional ecological and demographic information (e.g., movements, habitat use, spatial relationships, food habits, survival and reproduction) on mountain lions in the Badlands. The initial objectives of the pilot project were to: 1) implement and evaluate mountain lion capture protocols developed in South Dakota and adapt as necessary for use in the Badlands; 2) gain preliminary insights about lion ecology in the Badlands (e.g., extent of animal movements, habitat preferences, kill rates; and 3) test methods and gain insights about feasibility, logistics, sampling variation, performance of equipment, and other issues that are critical considerations for study planning (Oehler et al. 2008). This report summarizes information collected from reported mountain lion sightings in 2007, the 2007-08 hunting season, and initial findings from ongoing cooperative research efforts with SDSU.

## **Methods**

Reported mountain lion sightings (observation of the animal or its sign) by the public were documented and investigated by the NDGFD and/or WS, and ultimately entered into a Department web-based database for analysis and mapping. Sightings were classified according to their validity, as “Unfounded”, “Improbable unverified”, “Probable unverified” or “Verified”. Sightings were classified as “Verified” when there was physical evidence of the reported event (i.e., video of animal, photographs of lions or their tracks, scat, hair, scrapes, kill sites), or the reporting party was “vouched for” as a credible witness by Department personnel. Scat or hair found at reported sightings were shipped to the USDA Forest Service Rocky Mountain Research Station (FSRMRS), Missoula, Montana, to verify or refute lion presence via genetic analyses. Sightings were classified as “Probable unverified” when there was no physical evidence for the sighting but the description of the animal or the circumstance of the sighting was credible. Sightings were classified as “Improbable unverified” when there was no physical evidence for the sighting and the description of the animal or the circumstance of the sighting was suspect. In these instances, the probability of lion sighting was considered low. Sightings were classified as “Unfounded” when, upon investigation, they were determined to be something other than a mountain lion. In addition to sightings by the public, verified lion sightings documented by Department Biologists or other agency (WS, TRNP, TAT, and FWS) personnel, as well as locations of carcasses obtained from

illegal and legal shootings, and other incidentally killed animals, were recorded in the database.

The NDGFD carried out a state-wide mountain lion hunting season for North Dakota residents (31 August 2007 to 9 March 2008; 2007-2008 Small Game and Furbearer Hunting Proclamation). The state was divided into two management zones (Zone 1 and Zone 2; see Fig. 1). Zone 1 included the Badlands, associated MR Breaks and adjacent lands outside of Fort Berthold Reservation. Zone 2 included all areas outside of Zone 1 with the exception of tribal lands (Fort Berthold, Standing Rock, Turtle Mountain and Spirit Lake Reservations). A quota of five mountain lions was allowed in Zone 1; after the quota was filled, the season for this Zone was closed immediately. There was no limit on the number of animals taken in Zone 2, although the limit was one animal per season, per hunter. Any lion other than kittens (lions with visible spots) or females accompanied by kittens could be taken during the season. Beginning 1 December 2007, hunting with dogs was allowed. Any harvested lion that was taken was required to be reported to the NDGFD within 12 hours and the entire intact animal was submitted for analysis; legally taken animals were returned to the hunter following analysis. In addition to harvested lions, carcasses from legal and illegal shootings and incidentally-killed animals also were examined. As part of a cooperative agreement with TAT, mountain lions killed on the Fort Berthold Reservation also were provided to the Department for analyses.



**Figure 1.** 2007 Mountain lion management zones in North Dakota. Zone 1 = Badlands, Zone 2=Prarie

Mountain lion carcasses were weighed, sex determined, and age estimated based on tooth wear and fur color characteristics. Females were examined for evidence of lactation (Anderson and Lindzey 2000). Measurements were taken (Logan and Sweanor 2001), and bodies examined for wounds and presence of porcupine quills. Necropsies were performed to assess nutritional condition (Riney 1955), examine the reproductive tracts of females for past litter sizes, and to collect biological samples for cooperative research purposes. Gastro-intestinal (GI) tracts were sent to SDSU for analysis. Muscle tissue samples were sent to the USDA FSRMRS, for genetic analyses. Blood samples were provided to WS to test for tularemia and sylvatic plague (*Yersinia pestis*) as part of their agency's ongoing disease monitoring efforts.

## Results

A total of 230 reported mountain lion sightings were documented by the Department during 2007. Similar to the previous three years, sightings were reported in all months of the year with an overall higher number of sightings being reported during the fall/winter season (Table 1). However, the NDGFD documented a greater number of reports and higher percentage of verified reports than the previous three years (Table 2). By sighting classification, 61 reports (27%) were verified as being a lion (Table 2, Fig. 2). Of the 61 verified reports, 47 occurred in the Badlands, five in the adjacent MR Breaks region, and nine reports occurred outside of these two regions, in seven counties of central and western North Dakota. Verified reports included: 29 observations of tracks, 13 visual observations of the animal (four of which were verified based on credible witnesses that were "vouched for" by Department Biologists or Wardens), six wildlife kills made by lions (five radiocollared bighorn sheep (*Ovis canadensis*), one porcupine), six incidental kills of lions (four males, two females; Table 3), two domestic animal kills made by lions (cow and horse), one male found dead in Lake Sakakawea of unknown causes, one male found dead that was believed to be killed from a collision with a vehicle, one audio tape of a mountain lion, one male shot for protection of property purposes, and one female killed illegally. Seventy two reports (31%) could not be ruled out as being legitimate sightings, but lacked the evidence for verification. These 'Probable unverified' sightings occurred in 23 counties scattered throughout North Dakota. Fifty-three (23%) reports were classified as 'Unfounded'. Of the 'Unfounded' reports, the majority (36 reports [68%]) of people reporting mountain lion activity incorrectly confused canid tracks ( $n = 23$ ), sightings ( $n = 8$ ), wildlife kills ( $n = 3$  deer), domestic animal attacks ( $n = 1$  cow calf), or scat ( $n = 1$ ) with those of mountain lions. On ten occasions (19%), people incorrectly confused domestic house cat tracks ( $n = 1$ ), sightings ( $n = 8$ ), or scat ( $n = 1$ ) with those of mountain lions. The remainder of the reports classified as unfounded (seven reports [13%]) were due to visual observations of unknown animals ( $n = 4$ ) being mistaken for lions, horse scratches by barb wire ( $n = 2$ ) being mistaken for lion attacks, and tracks of livestock ( $n = 1$ ) being mistaken for lion tracks.

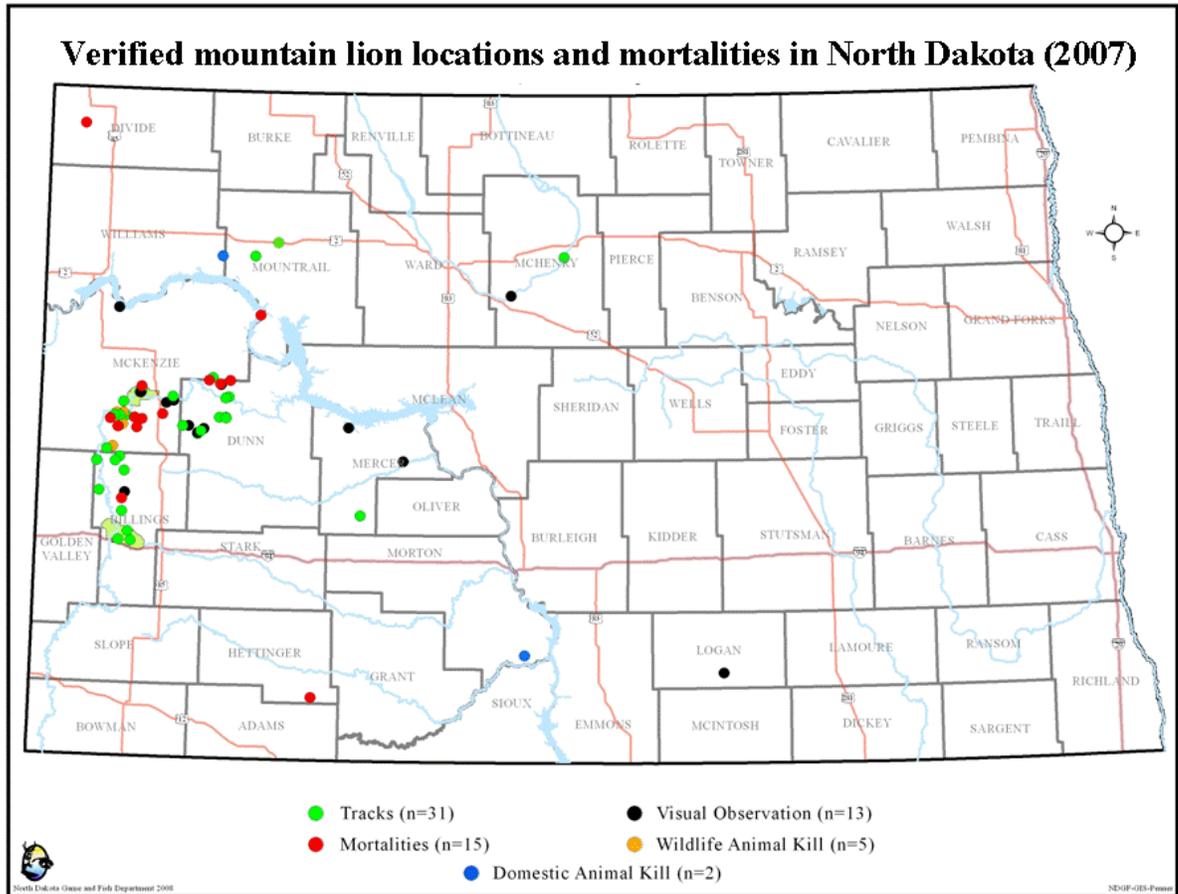
**Table 1.** Number of reported mountain lion sightings, 2004 – 2007 (including all sighting classifications: “Unfounded”, “Improbable unverified”, “Probable unverified”, and “Verified”), in North Dakota by month.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2007	12	17	15	15	13	20	17	15	26	34	19	26	229
2006	6	8	7	12	18	23	22	19	18	34	40	11	218
2005	9	6	5	3	5	8	17	14	12	12	14	15	118
2004	4	1	4	1	4	4	3	8	11	11	12	4	69
Total	31	32	31	31	40	55	59	56	67	91	85	56	634

**Table 2.** Number of reported sightings of mountain lions by sighting classification, 2004 – 2007 (column percentages are in parentheses).

Sighting Classification	2007	2006	2005	2004
Unfounded	53 (23)	53 (24)	30 (25)	13 (19)
Improbable Unverified	40 (17)	53 (24)	26 (22)	21 (30)
Probable Unverified	72 (31)	86 (39)	44 (37)	27 (39)
Verified	61 (27)	26 (12)	18 (15)	8 (12)
Pending*	3 (1)			
Total	229	218	118	69

\*Reports have not yet been classified.



**Figure 2.** Verified mountain lion locations, and harvest and non-harvest mortalities in North Dakota (2007)  $n=66$ .

The NDGFD received results from three scat samples that had been found at locations of reported sightings and sent to the USDA FSRMRS for analyses. The first sample was collected on 22 June 2007 at a radiocollared bighorn sheep kill site in the Badlands. The scat was confirmed to be from a male mountain lion. The second sample was collected in the Badlands near a suspected lion track on 13 October 2007. This scat was identified as being from a coyote (*Canis latrans*). The third sample was collected on 29 November 2007, at a potential scrape site in the vicinity of several reported sightings of the animal near Jamestown, North Dakota (Stutsman County); this scat was identified as being from a domestic house cat.

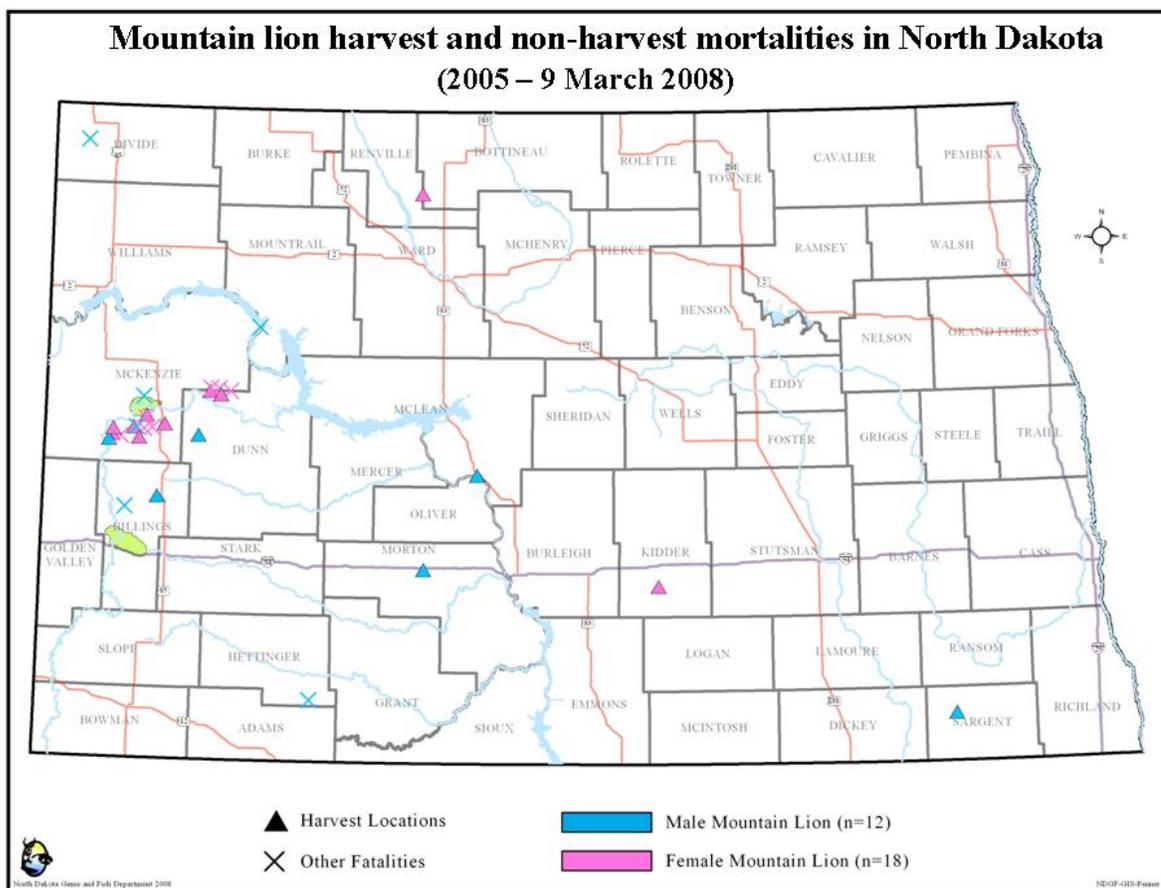
A total of six mountain lions were harvested in North Dakota during the 2007-08 mountain lion hunting season. The season for Zone 1 ended on 10 November 2007, when the quota of five animals was filled. Five female mountain lions (1 adult; 4 subadults) were harvested in Zone 1 (Table 3). Two of the subadult females (F23 and F24) were reported to have been traveling with two other lions at the time of their deaths. Female lion F19 was estimated to be a 4-year-old animal that had a past litter of two

kittens based on examination of her reproductive tract. One subadult male lion (M28) was harvested in Zone 2.

**Table 3.** Mountain lion mortalities in North Dakota (2007 – 9 March 2008).

Lion ID	Cause of Death	Date Harvested	Sex	Age	Weight (lbs)	County
M13	Incidental kill	1/15/07	M	4-5 months	42	McKenzie
M14	Incidental kill	1/30/07	M	4-5 months	48	McKenzie
F15	Incidental kill	2/18/07	F	10+ years	80	McKenzie
M16	Carcass found (Lake Sakakawea)	5/12/07	M	1-2.5 year old	---	Montrail
F17	Illegal shooting (kitten shot out of season)	5/27/07	F	6-8 months	46	Dunn/ McKenzie
M18	Legal shooting: Protection of property	5/30/07	M	2.0-2.5 years	112	Divide
F19	Legal harvest (Zone 1)	9/1/07	F	4 years	97	McKenzie
M20	Carcass found (Collision with vehicle)	9/11/07	M	1-2.5 years	84	Hettinger
F21	Legal harvest (Zone 1)	9/16/07	F	1-1.5 years	72	McKenzie
F22	Illegal harvest (Zone 1)	9/17/07	F	1-1.5 years	60	Dunn
F23	Legal harvest (Zone 1)	10/30/07	F	1-2.5 years	71	McKenzie
F24	Legal harvest (Zone 1)	11/10/07	F	1.5-2.5 years	84	McKenzie
F25	Incidental kill	12/12/07	F	1-2 years	78	McKenzie
F26	Incidental kill	12/12/07	M	4-5 years	102	McKenzie
M27	Incidental kill	12/17/07	M	Adult	152	Billings
M28	Legal harvest (Zone 2)	1/1/08	M	1.5-2.5 years	101	Sargent
F29	Incidental kill	2/13/08	F	Kitten	45	McKenzie

In 2007, eleven mountain lions ( $n = 6$  males,  $n = 5$  females) died from causes other than hunting mortality (Table 3, Fig. 2 and 3). One lion (M18) was shot legally for protection of property purposes (the animal had killed a domestic house cat, and remains of a second house cat were found in the animal's stomach). Seven animals were caught incidentally by trappers; of these, four lions (M14, F25, F26 and M27) were found dead in neck-cable devices and the other three animals (M13, F15 and F29) were euthanized due to trap/cable-device-related injuries that were believed to inhibit their ability to survive in the wild. Two animals were provided to the Department by TAT; one lion (F17) was shot illegally, and another lion (M16) was found dead in Lake Sakakawea. One lion (M20) was found dead, most likely from a collision with a vehicle.



**Figure 3.** Mountain lion harvest and non-harvest mortalities in North Dakota by sex (2005 – 9 March 2008)  $n=30$ .

Stomach samples from mortalities of six mountain lions located in North Dakota outside of the Badlands (2005-2008; F8, M9, F10, M18, M20, M28) were analyzed at SDSU as part of a study to document diets of lions inhabiting prairie habitats in the Dakotas (see Thompson et al. 2008). Two of these animals (F8 and M20) had multiple species present in their stomachs; beaver and rodent were found in the stomach of F8, and deer and porcupine were found in the stomach of M20. Deer was documented in the stomachs of F10, M9 and M28, and domestic house cat was documented in the stomach of M18. Porcupine quills were found on the extremities of four animals (F8, M9, M18, M20).

A genetic analysis conducted at USDA FSRMRS, comparing the North Dakota Badlands lion population to the lion population in the Black Hills of South Dakota, was provided to the Department (K. Pilgrim and M. Schwartz, Unpublished Report; D. Thompson Unpublished Data). The North Dakota mountain lion population had six unique alleles from that of the Black Hills population, showed a marginally significant genetic bottleneck, and based on assignment tests, none of the 14 samples that came from the Badlands population were immigrants from the Black Hills. However, an  $F_{ST}$  value of 0.05 indicated gene flow between the two populations. Furthermore, two lions (M11, a 3-4-year-old male, and F10, a 3-4 year-old female) harvested in Morton and Kidder Counties, located well outside of the Badlands (Fig. 3), were assigned to the Black Hills population, indicating they were immigrants from this region. Additionally, F10, a 3-4 year-old female lion, also harvested outside the Badlands in Renville County, appeared genetically different from both the Badlands and Black Hills lions. These findings suggest that lions have traveled into North Dakota from the Black Hills, and from other source populations.

## **Discussion**

Similar to past years, the distribution of verified lion sightings in 2007 occurred predominantly in western North Dakota, in the Badlands and vicinity, and to a lesser extent in other regions of the state. In general, the majority of reported sightings from 2004-2007 occurred during months associated with hunting activity (October and November), when a greater number of people traveling to, and hiking in, remote country throughout the state, increased the probability of mountain lion sightings. Of the 61 sighting reports that were classified as 'Verified', all were non-threatening observations of either the animal or its sign. In three cases, mountain lions were documented to have killed domestic animals, including a cow, a horse, and domestic house cats (killed by M18; Table 3). Kills of domestic species, occasionally occurring in North Dakota, continue to represent rare events. For example, of the 71 verified reports from 2001-2006, in only two cases were mountain lions documented to have killed domestic livestock; a sheep was killed by a mountain lion on one occasion, and a cow was killed on another occasion (NDGFD 2006 and 2007). Furthermore, of six gastrointestinal tracts analyzed from mountain lion mortalities in North Dakota, outside of the Badlands population (2005-present), five contained native prey, whereas only one animal (M18), as mentioned previously, had fed on a domestic house cat.

Although, the mountain lion population appears to be expanding its distribution into the MR Breaks region (NDGFD 2007), the greater number and higher percentage of verified reports recorded by the Department in 2007 is not indicative of state-wide population

increases or expansion. The overall increase in verified sightings is most likely due to increased efforts to document continued species presence in the Badlands, following harvest seasons, as well as part of an ongoing effort by the Department to assess lion predation on bighorn sheep. Verified reports in 2007 included those obtained by the Department Biologist conducting research on the bighorn sheep population ( $n = 9$  reports from four bighorn sheep killed by lions, three sets of tracks seen, and one visual observation of the animal), tracks observed during snow track surveys for the species by TRNP employees ( $n = 7$  reports), and two trappers who reported locations of lion snow tracks to the Department ( $n = 9$  reports) during the trapping season.

While verified reports alone cannot be used to document population trends, reports have provided the Department with valuable information on distribution and range expansion of lions in suitable landscapes, and potential travel routes of transient animals (NDGFD 2006, 2007), and these reports continue to provide the NDGFD with interesting information about mountain lions in the state. For example, on 6 October 2007, the Department received a digital trail camera photograph of a mountain lion kitten taken in Mercer County, in an agricultural and prairie-dominated landscape (Figure 2). The location of the camera was verified by a Department Conservation Officer and the digital photo was sent to Pallotta Design Productions, McKeesport, PA, to verify its authenticity. Based on the photo, this animal would be too young to survive on its own, and represents a potential family group east of the Badlands and about 16 kilometers south of suitable lion habitat in the MR Breaks region. Whether this is an isolated incident, or marks the beginning of range expansion by the species into non-traditional habitats is unknown.

Since the ending of the 2007-08 season in Zone 1 (10 November 2007), mountain lion presence continues to be documented in the Badlands. There have been 24 verified reports of mountain lion activity in this Zone, nine of which have occurred since 1 January 2008. These sightings included documentation of two unique females (from genetic analyses of two scats found in the Badlands) and two separate family groups. In addition to documenting continued presence of mountain lions in the Badlands with verified reports, in an effort to monitor the Badlands population, the NDGFD analyzed age and sex composition of lion mortalities. Anderson and Lindzey (2005) suggested that the effect of harvests on populations would differ depending on the age and sex composition of lions removed, and that an annual harvest composed of 10-15% of adult females appeared sustainable for a population of mountain lions in Wyoming. However, they cautioned that more isolated populations may respond differently to similar harvest rates. Based on all documented harvest and non-harvest mortalities in the Badlands ( $n = 20$  lions; two adults males, three adult females, two subadult males, seven subadult females, two male kittens and four female kittens), three females (15% of the mortalities) were breeding age and had produced at least one litter. While caution should be taken when drawing conclusions due to the limited sample size of harvested animals in a given year, based on initial analysis of age and sex composition data and continued documented presence in the Badlands, the lion population appears not to have been negatively impacted by the past three experimental hunting seasons and additional human-caused mortality.

The results of the genetic analyses indicated that lions likely recolonized the Badlands from multiple sources, which included individuals from the Black Hills population. The

fact that North Dakota has unique alleles from the Black Hills lions indicated multiple origins of this recently re-established population. Whether remnant individuals remained and bred in the Badlands in the 1900s, or immigrated from Montana and elsewhere, currently is unknown. The marginally significant genetic bottleneck that characterized the Badlands population is supported by the historic accounts of this species in North Dakota and years of unmanaged killing. Furthermore, the genetic analyses of two mountain lions (F10 and M11) harvested on the prairie in North Dakota during the 2006-07 season support the belief that lions traveling on the prairie-dominated landscapes are most likely dispersing or transient animals (NDGFD 2006, 2007), as apparently both animals migrated into North Dakota from the Black Hills population.

### **Acknowledgements**

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## Florida Mountain Lion Status Report

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The Florida panther (*Puma concolor coryi*) has been protected as an endangered species by the Florida Fish and Wildlife Conservation Commission (FWC) and the United States Fish and Wildlife Service (USFWS) since 1958 and 1967 respectively. Research and management activities were initiated by the FWC in 1981. Many state and federal agencies, as well as several private and non-governmental agencies, participate in panther recovery efforts today. Historically ranging throughout the southeastern United States, Florida panthers were reduced and isolated to a small population of <30 individuals in southwest Florida. To alleviate deleterious effects of low heterozygosity, genetic introgression was implemented in 1995 by releasing 8 female Texas pumas (*P. c. stanleyana*) throughout the Florida panther range. Preliminary analyses show genetic introgression has had a positive impact on the panther population via the reduction of several chronic morphometric and physiological problems. Additionally, Florida panthers have reoccupied vacant areas within their current breeding range as the population has rebounded to >100 individuals. Although several males have dispersed north into central Florida from the current breeding range in south Florida, no females have been documented outside of this core area since 1972. Habitat loss and fragmentation continue to be the biggest threat to the long-term survival and recovery of the Florida panther. However, growing populations of people and panthers in south Florida has led to increased conflict, predominantly in the form of hobby livestock depredations. Recognizing the potential for human-panther conflicts, an Interagency Florida Panther Response Team, consisting of the USFWS, FWC and National Park Service (NPS), was created in 2004 with the primary objective of creating a Response Plan to guide agencies responding to human-panther interactions and depredations. The Response Plan is expected to be finalized in 2008.

### Population Status and Monitoring

Based on known individuals and quantifying observations of uncollared panther sign encountered during field activities, we estimate the current Florida panther population at approximately 100. The population has been near this estimate for the past few years. Much of the available habitat in south Florida appears to be occupied and we documented eight transient and dispersed males in central and north regions of the state during 2005-2007. Four of these panthers were road mortalities; the northernmost male being recovered on I-95 on the Flagler/St. Johns County Line just south of St. Augustine on the east coast. This is roughly 240 miles from the known breeding range in south Florida. Four other panthers were confirmed by tracks or photos.

Florida panthers are captured using hounds from November through March when environmental conditions (e.g., cool temperatures and lower water levels) are more favorable. Since the first panther was collared in 1981, 164 panthers have been equipped with radio collars by FWC and Big Cypress National Preserve (BCNP). Three agencies (FWC, BCNP, Everglades National Park [ENP]) share aerial location duties within their respective monitoring area throughout the year on a 3 times-per-week schedule (Monday,

Wednesday, and Friday). Neonate kittens are handled at the den when approximately 2 weeks old. Since 1992, 265 kittens have been permanently marked with passive integrated transponders. Additionally, biological samples and morphometric data are also collected.

Road mortality and intraspecific aggression are the two most important mortality factors for Florida panthers. The number of annual road kills has mirrored the rising population trend. Nine, 11, and 15 road mortalities were documented in 2005, 2006, and 2007 respectively. The vast majority of these were panthers that were never handled before. Not surprisingly, road mortalities are occurring in areas without protective measures such as wildlife underpasses and fencing. Underpasses (43) are typically located adjacent to protected public lands where the majority of our capture efforts are conducted. Therefore, most radiocollared panthers are able to cross highways safely and are not as likely to be killed by vehicles. Conversely, 1, 4, and 3 intraspecific aggression mortalities were documented in 2005, 2006, and 2007 respectively. Intraspecific aggression is difficult to document unless the animal is wearing a working radio collar. This form of mortality is most commonly documented in the radiocollared population which resides predominantly in the areas protected with underpasses.

### **Human—Panther Conflict**

Florida has experienced an increase in human-panther conflicts over the past few years due, in part, to an increase in both the panther and human population in south Florida. Fortunately, all human-panther interactions have been benign sightings or encounters and there have been no human safety issues. Sightings, without verifiable evidence, can not be confirmed. Because sightings have low levels of risk to humans, few actions are warranted outside of public education. Likewise, encounters pose little human risk but still need to be verified. Outreach is the standard course of action imposed by FWC. Depredations on hobby livestock to include goats and sheep cause the greatest amount of conflict between humans and panthers.

### **Florida Panther Response Plan**

Prior to 2003, conflicts between people and panthers were virtually nonexistent. Two events involving repeated sightings and hobby livestock depredation in 2003 and 2004 respectively (Lotz 2005) prompted the regulating agencies (FWC, NPS, FWS) to initiate actions to manage concerns posed by these circumstances. These actions would evolve into the formation of the Interagency Florida Panther Response Team (Response Team) and the creation of the Interagency Florida Panther Response Plan (Response Plan).

The Response Team is comprised of biologists, law enforcement officers, public information staff and other agency representatives from the FWC, FWS, and NPS. The impetus of the team is to respond to human-panther interactions in such a way to ensure public safety and the continued existence and recovery of the Florida panther. The Response Plan mirrors the methodology used by many western states to manage their human-mountain lion interactions but also recognizes the special needs posed by the endangered status of the Florida panther. Since its inception in 2004, the draft Response Plan has been the guiding document for the agencies when dealing with human-panther

interactions. Six categories of interactions covered in the Response Plan include sighting, encounter, incident, threat, attack, and depredation (Table 1).

**Table 1.** Categories, definitions, and risk factors of Interagency Florida Panther Response Plan

<b>Category</b>	<b>Definition</b>	<b>Risk Factor</b>
Sighting	A visual observation or fleeting glimpse of a panther from a distance.	Low
Encounter	An unexpected direct meeting or a series of meetings over a short period between a human and panther. Panther exhibits non-threatening behavior.	Low - Moderate
Incident	An interaction between a panther and a human as described in an Encounter, except that the panther displays potentially threatening behavior.	Moderate – High
Threat	An unprovoked aggressive/predatory behavior toward a human that requires the individual to take defensive action to avoid direct contact.	High
Attack	A direct, physical contact between a panther and a human involving aggressive panther behavior.	High
Depredation	A panther that preys upon domestic pets (e.g., dogs, cats) or livestock (e.g., goats, pigs, horses, cows).	Low

Because the Florida panther is listed as a federally endangered species and the Response Plan allows for permanent removal from the wild and use of aversive conditioning techniques, which are classified as “take” under the Endangered Species Act, the Response Plan is subject to requirements of the National Environmental Policy Act (NEPA). The USFWS initiated NEPA and the drafting of the Environmental Assessment (EA) for the Response Plan in 2005. The final EA and Response Plan were submitted for publication in the federal register in March 2008 and will soon be finalized. Currently, the draft EA including the full Response Plan can be viewed at <http://www.fws.gov/verobeach/images/pdflibrary/Panther%20Response%20Plan%20Final%20EA%20101207.pdf>

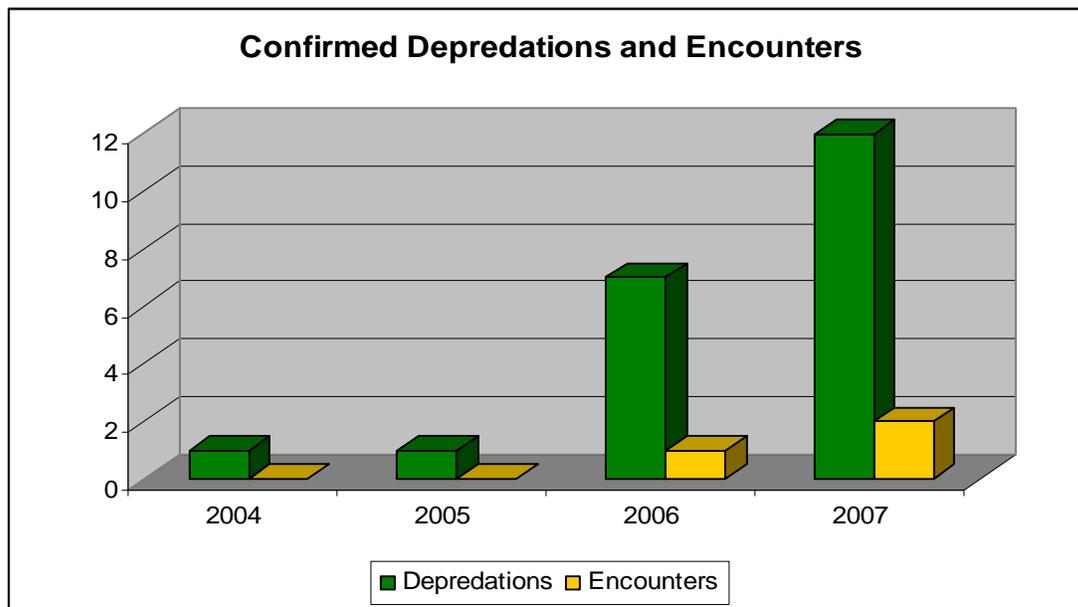
### **Public Education / Outreach**

While the Response Plan outlines actions the agencies will take to respond to human-panther interactions and depredations, public outreach and education are vital to minimize negative interactions and promote coexistence between humans and panthers. Therefore, several strategies have been developed to educate residents and visitors on how to coexist safely with panthers. Several public information meetings have been focused in areas that have potential for or have experienced conflicts (i.e., depredations). Additionally, *A Guide To Living With Florida Panthers* brochure outlining actions and precautions to take in panther country has been produced. Another successful campaign, organized by Defenders of Wildlife, involved building 3 “light load” livestock pens (fashioned from a portable car port) at two residences that have experienced livestock/pet loss and one at the Collier County Agricultural Extension Service for public demonstration purposes. These pens provide a secure enclosure for pets and livestock,

protecting them from predators. Many partners and private citizens assisted in constructing these pens

### Confirmed Encounters

There were 3 confirmed encounters from May 2005-April 2008 as defined by our Response Plan (Fig. 1). One encounter in 2006 involved two turkey hunters that were standing on a dike when a family group of 4 panthers, including 3 approximately 60-pound juveniles and their mother, approached a cross-over area near the hunters (FWC 2006). The juveniles became curious of the camouflaged-clad hunters and were dissuaded from approaching closer when rocks were thrown in their direction as the mother called to them from nearby cover. Two encounters occurred in Everglades National Park in 2007. In July, a 1.5-year-old kitten of a radiocollared female was observed lounging on a horizontal oak branch along a popular hiking trail. Park visitors found an egg shell on the ground and, thinking it was from a bird nest, looked up to find the nest and saw the panther instead. Several pictures were obtained before the trail was temporarily closed allowing the panther to come down of its own accord. The egg was from a turtle and the trail was opened the following day. In December a couple was returning to their vehicle and encountered a radiocollared panther standing on the boardwalk looking out across the saw grass marsh. The couple was at a T-junction and, after taking a few pictures, stepped back allowing the panther to pass by on the boardwalk.



**Figure 1.** Confirmed Florida panther depredations and encounters, 2004-2007.

### Confirmed Depredations

Depredations of hobby livestock (i.e., primarily goats) and pets have recently increased (Fig. 1). In 2005, 2006 and 2007, there were 1, 7, and 12 confirmed depredations or attempts respectively. By far the most common hobby livestock animals preyed upon by panthers were goats. Other animals attacked or consumed included turkeys, chickens, geese, emus, dogs, hogs, a miniature donkey, sheep, and fallow deer. In three of these

cases (a large breed dog, miniature donkey, goat) the intended prey animal survived. Radiocollared and non-radiocollared male panthers were identified as depredators. One radiocollared individual was removed to permanent captivity after being deemed a “threat” under the Response Plan (FWC 2006). Florida panther #79 habitually sought out domestic prey even after being relocated to the opposite end of his home range. Our actions were warranted based on the inability to alter this new behavior. Several residents had repeat depredation incidents after failing to heed suggested corrective measures.

### **Current Research**

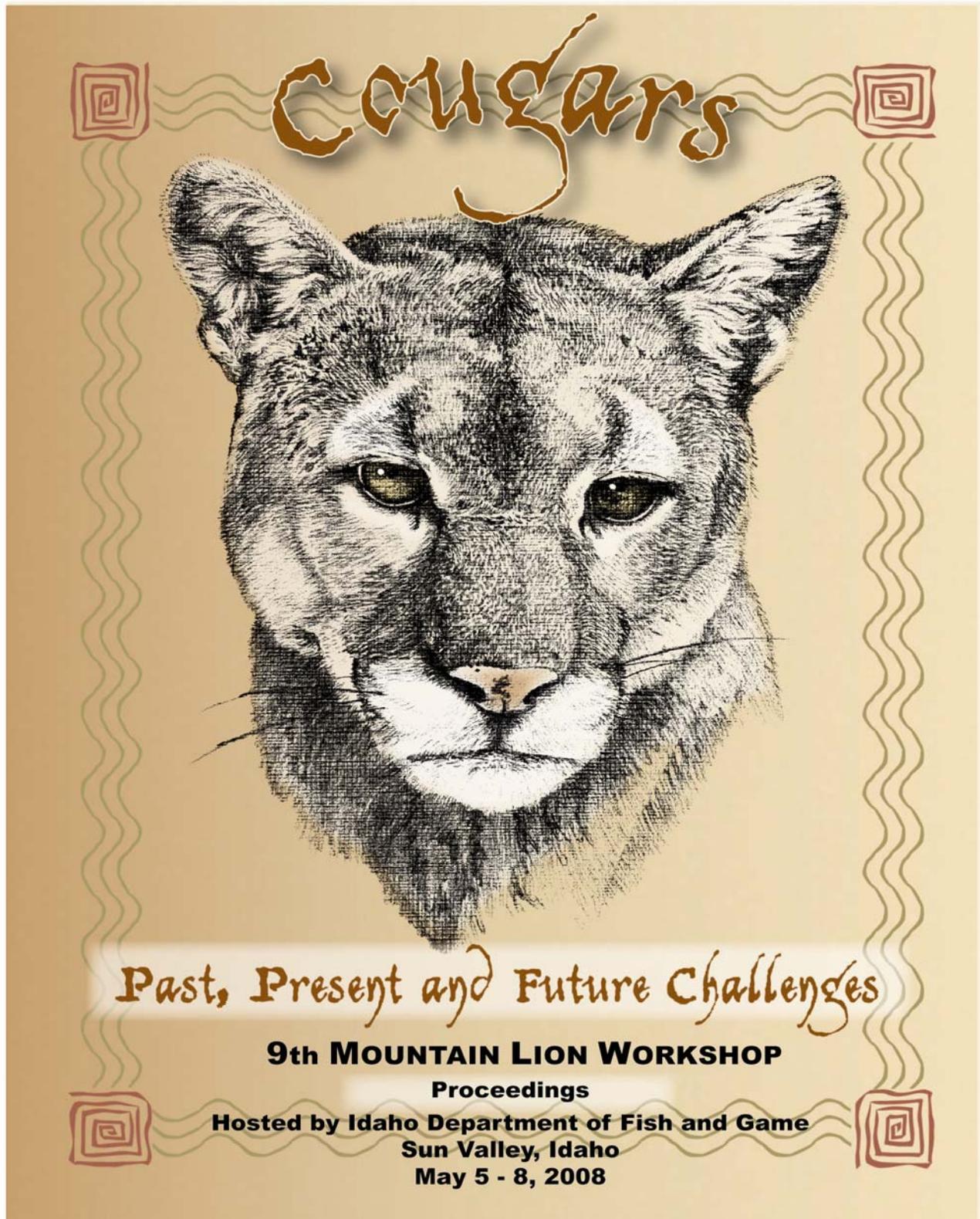
FWC’s current research goals are objective-driven to provide the information necessary to manage and conserve Florida panthers (FWC 2007). Current research objectives include, but are not limited to, evaluating the utility of new GPS collar technology, using GPS technology to collect resource-selection data, delineate movement patterns of panthers along the urban-wildland interface, determine movement and kill rates, quantifying denning habitat characteristics, estimating multiple demographic parameters, and developing a population viability model. Additionally, assessment of the genetic introgression project continues.

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# Interactions with Humans at the Urban Interface



## **Distribution and Movements of Mountain Lions Associated with Human Residential/Urbanized Areas in North-Central Arizona**

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**ABSTRACT** Sightings and other encounters between humans and mountain lions have increased in western North America during recent decades, particularly near and within residential/urbanized areas. How the predator uses these areas is poorly understood. We present findings of research between January 2005 and September 2007 regarding distributions and movements of mountain lions within wildland and residential/urbanized habitats in north-central Arizona. We captured 16 adult ( $\geq 2$  years old) mountain lions from hunted populations by trailing them with hounds or using leg-hold snares. We attached radiocollars with GPS receivers to mountain lions captured within  $\leq 10$  km of human residential/urbanized developments to estimate overlap of distributions and movements with these areas. Receivers were programmed to attempt position fixes every 7 hours, and monitoring durations of individual mountain lions ranged between 1 and 22 months. Success of attempted GPS position acquisitions was about 75%. Four mountain lions occupied only wildland habitats. Distributions and movements of 12 overlapped with residential/urbanized areas;  $<1$  to  $>96\%$  of total GPS location fixes acquired for individuals occurred within these areas. Human developments and residences encroach on mountain lion habitat, and our findings suggest that mountain lions do not necessarily avoid entering residential/urbanized areas. We hypothesize that mountain lions might enter such areas frequently, just travel through them, explore them briefly and leave, or inhabit them extensively. Humans may encounter mountain lions comparatively infrequently, even when distributions and movements of the predators overlap extensively with areas of residential/urbanized developments.

## Demographic and Landscape Influences on Cougar-Human Interaction in Western Washington

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**ABSTRACT** Cougar (*Puma concolor*)-human interaction, defined as a sighting, encounter, depredation, or attack, is an increasing concern for wildlife managers. Washington has experienced high levels of interaction since 1996 (>350 confirmed reports per year) and the Puget Sound region is a microcosm of cougar management issues occurring throughout western North America. Cougar population increases are frequently cited as the reason for higher levels interaction, but there is little evidence to support this assertion. Alternative explanations may be found in cougar-habitat relationships and the behavioral differences between different demographic classes of cougar. We are in year Three of a proposed four-year study examining the role of landscape features and cougar demographics as possible contributing factors to cougar-human interactions. Cougars are captured, outfitted with Global Positioning System (GPS) radio collars, and intensively monitored year-round using radio telemetry and GPS. All reports of cougar-human interaction within the study area received by the Washington Department of Fish and Wildlife are investigated, landscape features documented, and demographic information is collected if possible. We are utilizing multivariate Resource Utilization Functions (RUF), Geographic Information Systems (GIS), and paired t-tests to examine the relationship of various landscape features and characteristics to cougar space use, movements, and interactions with people. We are utilizing ANOVA fixed-effects models and the RUF methodology to examine the propensity of different demographic classes to interact with people. To date, we have captured 31 adult and subadult cougars and 21 of 23 individuals (cougars captured prior to winter 2007-2008) have utilized the urban-wildland interface and suburban environments to some extent. Preliminary findings suggest use of the urban-wildland interface may increase in proximity to rivers, streams, and wetlands and that all demographic classes of cougar interact with people. Research findings should assist wildlife managers and urban planners with the development of direct and indirect management strategies and education efforts that work to minimize cougar-human interaction, improve management, and foster an attitude of coexistence.

## **Cougar Spatial and Habitat Use in Relation to Human Development in Central Washington.**

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**ABSTRACT** In recent decades, residential development has been increasing and human-wildlife interactions are becoming more common. We captured and collared 42 cougars (*Puma concolor*) from 6 weeks old to adult age and monitored their movement patterns and their spatial organization from 2001-2008 in the foothills of the North Cascades near Cle Elum, WA. We fitted cougars >2 years of age with Lotek 4400 and Televilt GPS collars programmed to collect 4-6 location fixes per day all year. We have accumulated over 27,500 location fixes from 21 cougars. Relative to other areas in Washington, Cle Elum has a lightly hunted cougar population. We found the resident adult cougars were on average >6 years of age. Male cougars we have monitored have scars from fighting, most likely from defending territories from other sub-adult or resident cougars. Home range boundaries appear stable. When a cougar is killed, the next cougar to occupy that area maintains similar home range boundaries and movement patterns. In Kittitas County, there are relatively few human/cougar incidents as Washington Department of Fish and Wildlife receives approximately 4-11 reports per year and only a small portion are verified as cougars. Preliminary analysis of several individual cougars collared for >4 years display a shift in cougar movements and a withdrawal from areas of large-scale development. Understanding how cougars utilize areas where human development is expanding in cougar habitat may offer tools for managers to potentially minimize human/cougar conflict.

## **Challenges and Opportunities Facing Florida Panther Conservation – Can We Increase the Size of the Box?**

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Since a breeding population of Florida panthers (*Puma concolor coryi*) was officially verified in 1978 south of Lake Okeechobee, all panther conservation efforts have been directed towards ensuring the survival of this small population. These efforts have included preservation of >230,000 acres of habitat, installation of wildlife crossings in highways, improved habitat management practices that benefited both panthers and their prey, and panther genetic restoration to mimic natural gene flow into this isolated and small population.

The panther population has grown over the past 20 years from as few as 20-30 to 80-100 cats today. The reproducing portion of this population occurs south of the Caloosahatchee River, a dredged waterway that flows from Lake Okeechobee westward to the Gulf of Mexico, in a fairly contiguous 1.7 million acres that is still threatened by habitat loss and/or degradation. Female panthers and all known reproduction have been documented only south of this river; young males occasionally cross it and disperse northward into south-central Florida (Maehr et al. 2002a).

Florida's human population nearly doubled in size from 9.7 million people in 1980 to >18 million in 2006 and this growth has put increasing pressure on wildlife habitat and rural land uses such as cattle ranching and agriculture. Local and State conservation land buying programs continue to preserve habitat but these programs cannot keep pace with the rapid inflation of property values. Average price per acre has risen from \$3,700 to \$12,000. The remaining 500,000 acres in private ownership are not only threatened by development, but by loss of functionality, due to habitat fragmentation or severing of key linkages among habitat patches. According to population viability models, a population of 80-100 panthers is minimally viable over a 100 year projection; a reduction in size below 50 animals is in danger of extinction (Maehr et al. 2002b, Root 2004, and Kautz et al. 2006). The current breeding range is 70% publicly-owned and if we were to lose the remaining 30% (either direct loss or loss of functionality), the population would shrink in size.

Purchasing panther habitat has worked well in the past, but funds are limited. Rising property prices and a weak economy are creating conditions where conservation land purchases are not able to secure large tracts and cannot compete with other land development pressures. A new conservation tool is the Rural Land Stewardship (RLS) program that provides incentives for private property owners to maintain wildlife habitat, wetlands, water recharge areas, and agriculture on their lands. Development is allowed on less environmentally-sensitive lands in exchange for preservation of lands with higher

natural resources value. Each acre of land has layers of potential uses ranging from conservation to residential; the most environmentally sensitive lands were mapped as Stewardship Areas and less environmentally sensitive properties were mapped as Receiving Areas. “Credit values” associated with these land-use layers are the currency of the RLS program. Receiving Areas can “receive” new development but only when appropriate credits have been secured to offset the development footprint. Large development footprints or developments that seek to convert lands with high natural resource values will require a greater number of credits. Credits are generated by stripping layers of potential uses off of land within the Stewardship Areas and these credit transactions are formalized through permanent easements.

One of the first counties to adopt a RLS program was Collier County in southwest Florida. Collier County’s RLS 196,000 acre boundary overlaps extensively with occupied panther range. This program has been successful at creating permanent conservation easements on >20,000 acres of panther habitat since 2003. As an example, to create the Town of Ave Maria (4,995 acres), the developer needed to permanently protect areas that were approximately 3.5 times greater than the size of the town. These lands (17,400 acres) are permanently protected from further development, but existing uses can continue (agriculture, cattle). Expansion of this or similar programs at a regional level, more conservation land purchases, and continued panther and habitat management may create opportunities to expand the panther population northward from its current breeding range. Collier’s RLS plan is being closely watched by other counties and large landowners north and south of the Caloosahatchee River to see if that process may work for them.

Panther habitat south of the river may be at carrying capacity, so to foster further increases in population size, we need to look to the north. Thatcher et al. (2006) examined areas north of the Caloosahatchee River and factored in road densities, human populations, habitat types, and other variables to delineate large areas of potential habitat. Potential panther habitat to the north is not as contiguous as that found to the south and the landscape has been altered to a greater degree as well. There is a greater network of highways within and between the potential habitat patches and no wildlife crossings currently exist on these roads. Significant acreages have been cleared of forest habitats to improve conditions for cattle ranching.

Panthers may adapt to these different habitat conditions as long as there are some areas with enough cover for den sites, rest sites and stalking prey. Restoration will be needed to provide for these cover elements where they are lacking, and where these features currently exist, management practices should be encouraged to maintain this cover.

Although we know that a few young male panthers disperse north of the Caloosahatchee River, these cats tend to wander widely. If females were present in this area, panthers would establish permanent home ranges and these home ranges would overlap or adjoin areas with people. Education and outreach will be a critical component of any management actions that lead to more panthers. Success will not be achieved without public support; management actions to enhance the panther population north of the

Caloosahatchee River will be dependent upon this stakeholder support, habitat protection, habitat restoration and adequate agency resources to deal with human-panther conflict issues as they arise.

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## Puma Movements Relative to Housing Density in Southern California

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**ABSTRACT** The puma (*Puma concolor*) is widely distributed throughout the western U.S. However, expanding human development is increasingly encroaching on puma habitat throughout the western U.S., which may isolate breeding populations and increase the potential for human-puma conflicts. We studied the movements of pumas relative to a gradient of human housing densities (public, undeveloped private, rural, exurban, suburban, and urban land uses) in southern California. Our goal was to better understand how the regional puma population will be affected by increased development projected to occur in future decades. We collected over 43,000 locations from 31 pumas wearing global positioning system (GPS) telemetry collars in Orange, Riverside, San Diego, and Imperial Counties in southern California. Current estimates of housing density were developed from U.S. Census Bureau data. Projections of future housing densities were developed with a supply-demand-allocation approach using patterns estimated from historical development patterns and parameters reflecting accessibility to human infrastructure like roads. Most puma locations were associated with public land (65%), undeveloped private land (14%), and rural land (14%). At the study-area scale, pumas selected for public land, used undeveloped private and rural areas in proportion to their availability, and selected against areas with housing densities that had less than 40 acres per unit. Approximately 9% of our puma locations occurred in areas that were projected to become suburban or urban areas in 2030. Not surprisingly, the future of pumas in the southern California landscape is dependent on public land. Therefore, maintaining functional connectivity between patches of public land should be a high conservation priority in this highly urbanized landscape. For example, a critical linkage between pumas inhabiting the Santa Ana Mountains and the Laguna Mountains appears highly threatened by development projections by 2030. Future analyses include: (1) examining the response to human development and other habitat features at finer spatial scales, and (2) using these empirical results to build a habitat model to predict how human development will affect puma distribution at a broader spatial scale that encompasses the western U.S.

## Prospects for Mountain Lion Persistence in a Complex Urban Landscape in Southern California

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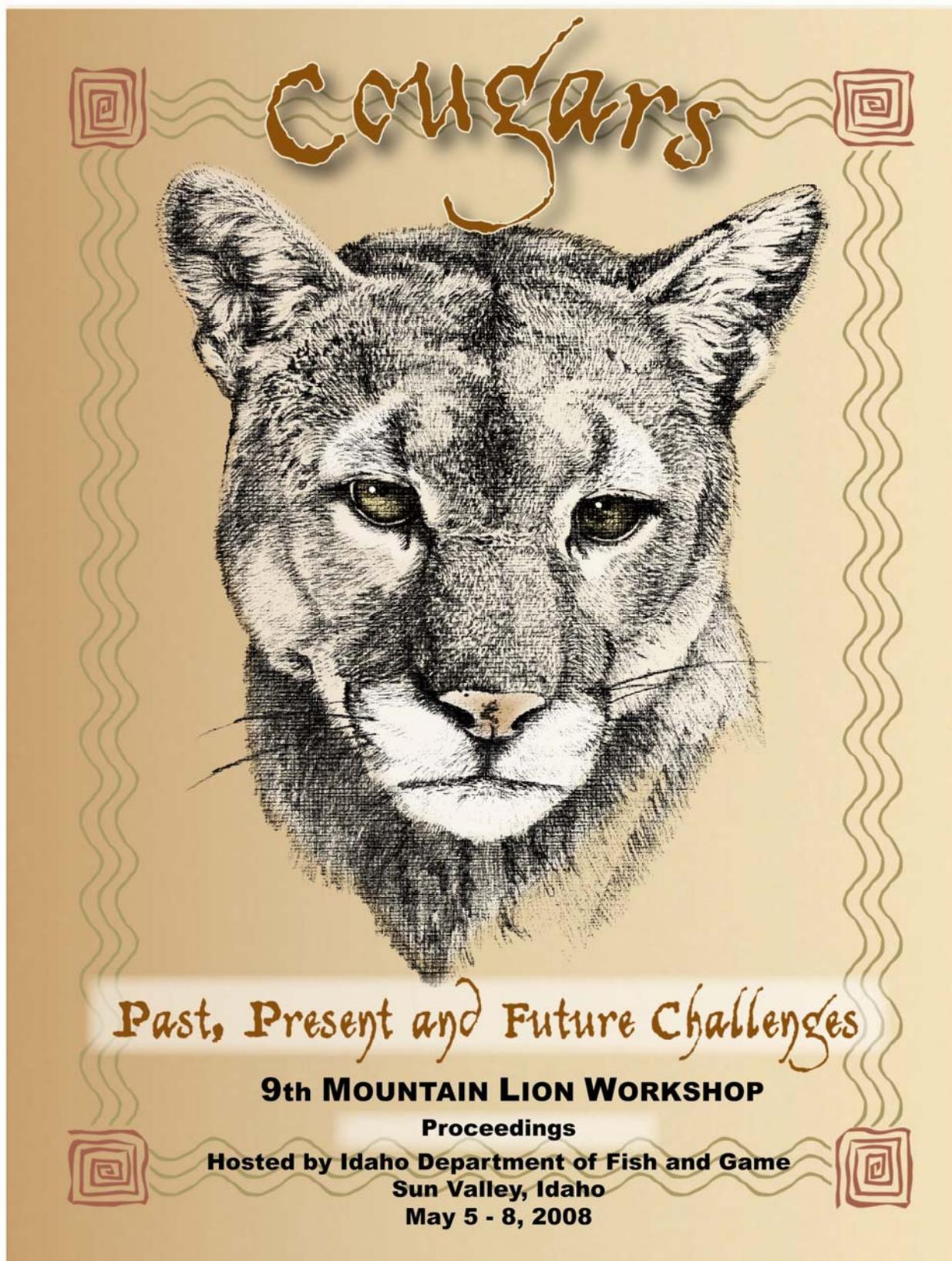
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**ABSTRACT** Because of their extreme spatial requirements, large carnivores such as mountain lions represent a significant challenge for conservation, especially in urban areas where habitat loss and fragmentation are particularly severe. Since 2002, we have been studying the behavior and ecology of mountain lions in the urban landscape of Santa Monica Mountains National Recreation Area (SMMNRA) north of Los Angeles, CA. From the beginning of the study, we assumed that none of the remaining blocks of habitat were sufficient for a functioning population of mountain lions, and therefore that successful movement across freeways and other barriers was critical for long-term persistence. Although two individuals successfully crossed one freeway, none of the 9 radiocollared lions have crossed highway 101, the largest barrier that separates the Santa Monica Mountains from likely source populations to the north. The first mountain lion in the study has survived and even thrived for 5+ years, but 9 of the 11 lions documented in the study so far have died: Two from anticoagulant rodenticide poisoning, two from vehicle collisions, and five, including two females, from fights with adult males. We were able to radio-track one litter of 4 kittens from 4 weeks old through their first two years, and although all four survived the death of their mother at one year, only one survived past 25 months. The two male kittens appeared to be attempting to disperse from the territory of an adult male, but they were thwarted by roads and development. Anthropogenic barriers to movement and dispersal may increase the frequency of intraspecific strife. In this area, we also found widespread exposure of mountain lions to anticoagulant rodenticides, as 7 of 8 animals tested were positive for 2-4 different compounds. Despite these threats and the lack of known freeway crossings, mountain lions persist across the landscape, and we continue to document new animals using remote cameras. Through working to maintain and enhance connectivity, preserving remaining habitat, and educating local communities about mountain lion behavior and ecology, we hope to continue to fulfill the National Park Service mandate of preserving all species in the parks, even mountain lions in an urban park like SMMNRA.



# Habitat Use and Movements



## Novel Spatial Tools for Connectivity Conservation: A Case Study Using Cougars in Southern California

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**ABSTRACT** Additional management of cougars (*Puma concolor*) in North America focuses almost entirely on reducing conflicts with humans by reducing cougar populations – the kill strategy. While conservation is often mentioned or inferred within a statewide program to traditionally manage cougars, explicit strategies to achieve long-term conservation goals for the species are simply not discussed. There appears to be an overly simplistic presumption that as long as sport-take (or other control) efforts are sustainable, then conservation has been achieved. We argue that these “traditional kill strategies” not only do little to reduce conflict, but more importantly do little to conserve the species. In truth, the conservation of wide-ranging taxa depends critically on planning efforts that consider both habitat and connectivity needs of the target species. Fragmented landscapes that include expansive areas of urbanization can further complicate analyses and realistic conservation goals. Despite these challenges, contemporary efforts tend to rely on overly-simplistic decision rules and tools (e.g., GIS overlays, least-cost pathways, etc.). We believe the use of theoretically grounded spatial tools that permit a more integrated analysis of the landscape are needed in order to produce defensible land-use plans. We will present a suite of habitat and landscape connectivity models that were developed to better inform long-term conservation strategies for cougars in a highly fragmented region of southern California. The models were developed within the 35,000 km<sup>2</sup> study area using empirical and expert-based information to derive spatially-explicit models of core and dispersal habitats. These models were then integrated to predict important linkage zones among core areas using models from electronic circuit theory (i.e., Circuitscape), which predicts movement probabilities given the quality and configuration of dispersal habitat between core areas. Probabilistic model outputs were used to quantitatively compare the value of alternative pathways, and evaluate the implications of continued habitat loss and fragmentation. These results both illustrate an integrated approach to habitat conservation planning, and provide a framework to test *a-priori* hypotheses regarding animal movement. The portability of these principles can serve as a framework for long-term planning for this and other species in various regions in North America.

## Daily Movement Distances of Florida Panthers (*Puma concolor coryi*) Assessed With GPS Collars

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**ABSTRACT** We are reporting a preliminary assessment of movement distances of Florida panthers (*Puma concolor coryi*) as part of an ongoing GPS collar study in southwest Florida. To date, fine-scale movements of panthers have not been investigated and as such, we used datasets from 6 collars deployed on female ( $n = 2$ ) and male ( $n = 4$ ) panthers with schedules set to obtain fixes at 1 or 2 hour intervals. We analyzed the daily movement distance (DMD) for each panther by randomly selecting 4 24-hour periods within each month. Collars averaged 75.8% successful locations on the 253 selected days. Panther DMDs averaged 7.90 km (range 0.30-24.6 km,  $SE = 2.7$ ) per day traveling 0.33 km/hour. Male and female DMDs averaged 9.30 ( $SE = 1.9$ ) km at 0.387 km/h and 5.09km ( $SE = 1.7$ ) at 0.212 km/h, respectively. We found no statistical difference between the sexes (Wilcoxon rank sum  $W$  test,  $W = 18.0$ ,  $P = 0.1052$ ), likely an artifact of our currently small sample size. Collection of data from additional panthers will improve DMD estimates, define travel routes within home ranges, and assist in differentiating individuals by track survey and sign.

## Potential Habitat and Dispersal Corridors for Cougars in the Midwest

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**ABSTRACT** Increasing cougar (*Puma concolor*) presence in the Midwest represents a growing management concern for wildlife biologists. However, with the exception of ongoing research in the Black Hills, no studies have been conducted regarding potential cougar habitat and dispersal corridors in the Midwest. Our objectives were to model potential habitat and dispersal corridors for cougars using an expert-opinion survey, geospatial data, and a GIS. Five geospatial data layers were used in the model: land cover, digital elevation models, roads, streams, and human density. Based on matrices of pair-wise comparisons involving these data layers, 11 expert biologists were surveyed to rank combinations of habitat factors in order of importance to potential cougar habitat in the Midwest. We evaluated surveys using the Analytical Hierarchy Process and used a GIS to analyze data and create a map of potential cougar habitat in a 9-state portion of the Midwest just east of established cougar range. About 8% of the study region contained highly favorable habitat ( $\geq 75\%$  favorability) for cougars; Arkansas (19%) and Missouri (16%) had the most potentially favorable habitat. We identified 6 large, contiguous areas of highly favorable habitat for cougars ( $\geq 2,500$  km<sup>2</sup> in size with  $\geq 75\%$  habitat favorability). Based on this habitat model, we used least-cost pathway methods to create potential dispersal corridors for cougars from established western populations into the interior Midwest. The most-likely least-cost pathways started in western Texas and went to areas of suitable habitat in the Ouachita and Ozark National Forests. Additionally, we created least-cost pathways to 30 locations of known cougar occurrence in North Dakota, Nebraska, and Missouri. Our models represent the first large-scale assessment of cougar habitat and dispersal potential in the Midwest and serve as a baseline for conservation and management efforts.

## Refining the Use of GPS Telemetry Cluster Techniques to Estimate Cougar (*Puma concolor*) Kill Rate and Prey Composition

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**ABSTRACT** Recent advances in global positioning system (GPS) radio-telemetry technology have created promising new opportunities for increasing sample size and reducing field efforts when estimating parameters of predation for large carnivores. Clusters of relocations in close proximity obtained from GPS radiocollars deployed on cougar (*Puma concolor*) can be used to identify potential kill sites. The number of prey found by visiting all clusters in a monitoring period can be used to estimate kill rate directly, or models can be employed to indirectly estimate kill rate by identifying kill clusters from GPS data. Extending kill rate models to allow indirect estimation of prey composition in a multi-prey setting has been suggested, but not attempted. We used data from 1,735 visits to GPS telemetry clusters and 637 prey >10kg found at clusters in west-central Alberta to further explore and refine indirect and direct GPS telemetry cluster techniques for cougar. We developed logistic regression models to identify kill sites (prey >10kg) from GPS data and multinomial regression models to identify the prey species at a kill cluster. The predictive capacity of each model was assessed using k-fold cross validation. The top logistic regression model had good classification success (86%), and 5-fold cross-validation at this cutoff revealed that it was capable of estimating cougar kill rate to within an average of +8.67% ( $SD = 5.56$ ) of true values. The top multinomial model also had reasonable classification success (75%), but it over-predicted the occurrence of primary prey (deer) in the diet and under-predicted the consumption of alternate prey (e.g., elk and moose) by as much as 100%. Simulated visits to all clusters in our dataset with a model-estimated kill probability of 0.15 or higher revealed that we could reduce the number of clusters visited by as much as 50%, while still retaining 91.6% of all kill clusters. Although indirect GPS telemetry cluster techniques can be usefully applied for overall kill rate estimation, they poorly estimate diet composition. Therefore, we recommend using model-directed field visitation to estimate kill rate and prey composition for cougar in multi-prey systems.

## Does Rural Development Fragment Puma Habitat?

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In western North America, human population has been increasing and many rural areas rapidly urbanizing (Theobald 2005, U.S. Census Bureau 2006), encroaching upon available habitats for large mammals. Highways, agricultural, and suburban development threaten to fragment quality habitat and undermine the viability of wildlife populations (Andren 1994, Noss et al. 1996, Crooks 2002). Many rural areas have been transformed by low-density “exurban” development, characterized by 2- to 16<sup>+</sup>-ha (5- to 40<sup>+</sup>-acre) residential subdivisions (Duane 1996, Theobald 2005). Puma (*Puma concolor*) sightings and depredations on pets and livestock indicate pumas use developed rural areas (CDFG 2006), but the habitat value of these areas is questionable.

Habitat fragmentation may occur at different hierarchical scales, potentially creating patches of low-quality habitat within individuals’ home ranges (Andren 1994), producing a “source-sink” condition at the population level, or disrupting landscape-level connectivity, which is essential for sustaining fragmented subpopulations (Hansson 1991). In a source-sink system, offspring produced in quality, “source” areas disperse into “sink” areas of mixed or low-quality habitat, associated with high mortality or inadequate resources, and unable to independently support populations (Pulliam 1988). Areas of coastal southern California have reached a critical point of fragmentation in which remaining high-quality source areas are too small to sustain viable puma populations, and have become separated by dense development and highway systems (Hunter et al. 2003, Riley et al. 2005, Beier et al. 2006).

We initiated a study in a rapidly developing rural region to examine whether low-density rural development functionally fragmented puma habitat. We asked whether rural development was likely to create demographic sinks, by analyzing puma survival and dispersal in undeveloped timberlands (*hereafter, undeveloped zone*) versus exurbanizing

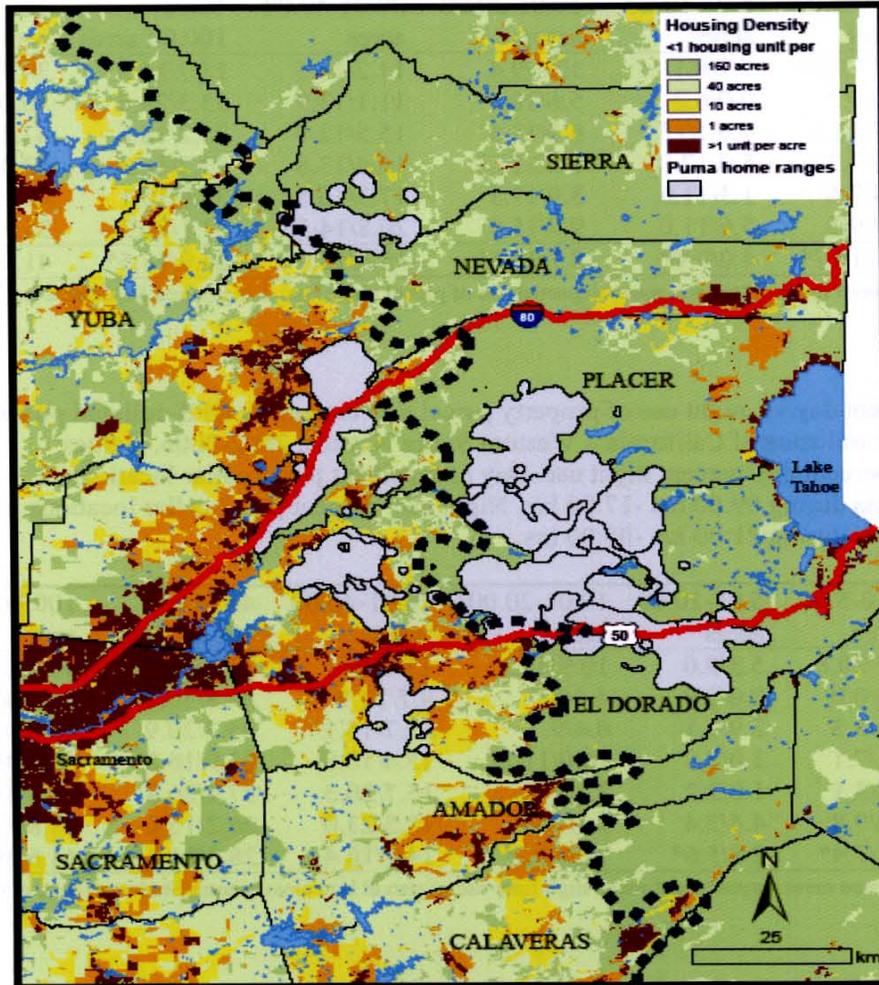
rural areas (*hereafter, developed zone*) of the same region. We tested whether anthropogenic and natural barriers limited puma movements and, thus, connectivity within landscapes. Finally, we examined whether developed-zone pumas preferentially used or avoided diminishing size-classes of residential property parcels within animals' home range areas. We asked whether pumas' use of parcels by size differed between day and night, suggesting responses to human activity levels. We focused on this wide-ranging species to identify threats to habitat connectivity likely to impact local wildlife communities (Noss et al. 1996, Terborgh et al. 1999), and to facilitate regional conservation planning.

## **Study area**

We conducted this study in Sierra, Nevada, Placer, El Dorado and Amador counties, in California's western Sierra Nevada Mountains and foothills. The western portion of these adjoining rural counties borders the agricultural Central Valley and the Sacramento metropolitan area. Elevation ranges from sea level in the west to over 2500 m at the Sierra Nevada crest. River canyons running roughly east-west separate mountain ridges in the higher elevations. Most private and residential lands are in the western foothills, characterized by oak-dominated (*Quercus* sp.) woodlands and chaparral. Eastward, vegetation transitions with rising elevation to conifer forests. This area is primarily non-residential timberlands, networked by logging roads. An urban/wildland interface corresponding to housing density on private versus public lands, typically national forests, transected our study area and was used to define the "developed" versus "undeveloped zone" (Fig. 1). Most of the counties' areas provide puma habitat, excluding only valley agricultural lands, urban areas, and the high elevation zones of the Sierra crest.

The area supports populations of mule deer (*Odocoileus hemionus*), black bear (*Ursus americana*) and puma, but represents a region of ecological concern. Large, contiguous regions at high elevations are protected from land conversion as national forests, wilderness and other public land designations, while other areas are privately managed timberlands. In contrast, the western foothills are largely privately owned. Traditional grazing land is being converted to ranchette-style settlement, or other uses such as vineyards and orchards. The area is intersected north-south by high-traffic highways US Route 50 and I-80, which serve as corridors for development emanating from the Sacramento metropolitan area.

Placer County had the fastest growing human population in California with a projected 27.6% increase from 2000 to 2005 (US Census Bureau 2007). Population increased by 9.6%, 13.1%, and 6.9% in Amador, El Dorado, and Nevada Counties respectively, during the same period. In Nevada County, the amount of undeveloped land zoned for residential or commercial development was 3.5 times the county's developed land area (Walker et al. 2003). Over 60% of El Dorado County's undeveloped private land was zoned for residential (0.4 to 8-ha or 1- to 20-acre) or exurban (8- to 16-ha or 20- to 40-acre) development (Stoms 2004). In Placer County, 93% of the foothills were privately



**Figure 1.** Approximate urban-wildland interface dividing developed and undeveloped zones of puma study area in California's Western Sierra Nevada, 2002-2006. Housing densities are from California Dept. of Forestry and Fire Protection dataset. CEN00BLM03\_1 Kernel density home ranges of 13 collared pumas are shown.

owned, of which over 50% were zoned for rural residential or urban land use (Stralberg and Williams 2002).

## **Methods**

### **GPS collars and capture**

During January 2002 to May 2005, we deployed GPS collars on 19 pumas. Eight Televilt PosRec C600 collars (TVP Positioning AB, Sweden) with 1- or 2-hour GPS fix intervals were fitted on pumas, and 2 PosRec C300 collars with 12-hour fix intervals were placed on juveniles. After the first year of study, we used Telonics (Mesa, AZ) GPS collars with Advanced Research and Global Observations Satellite (ARGOS) uplink, and 3-hour fix intervals. Nine Telonics ARGOS collars were deployed on pumas, which transmitted their 6 most recently stored locations a maximum of once every 2 weeks for internet download, allowing limited tracking in lieu of aerial telemetry. All collars were equipped with VHF beacons, mortality sensors, and automatic drop-off mechanisms, and detached at pre-programmed dates. We downloaded all stored GPS locations from retrieved collars to database files. We worked to collar male and female pumas, adults and subadults, and pumas living in the undeveloped and developed zone. We considered male pumas > 30 months old, and females > 24 months old to be adults, due to potential for reproductive activity (Logan et al. 1996), and younger pumas to be subadults.

To capture pumas, we conducted extensive track surveys on unpaved roads on public and private lands. We recorded GPS locations of all puma sign, track age, width of front and rear heel pad, and notes on the suspected individual. Pumas were treed by trained hounds and chemically immobilized with Capture-All 5 (5 parts ketamine hydrochloride to 1 part xylazine hydrochloride) or Telazol (tiletamine and zolazepam (100 mg/mL solution); Fort Dodge Animal Health, Fort Dodge, Iowa) at dosages in accordance with the CDFG Wildlife Restraint Handbook (2000). Drug was delivered using Pneu-Dart guns and darts (Pneu-Dart Inc., Williamsport, PA). We took blood and hair samples, body measurements, notes on condition, determined age from tooth wear and gumline recession, and fitted pumas with ear tags and collars, following CDFG animal welfare protocols (CDFG 2000). Collared pumas were tracked using ground-based VHF telemetry and monthly or semi-monthly telemetry flights. Pumas wearing ARGOS-enabled collars were also monitored using satellite transmitted GPS fixes.

We estimated the precision of GPS collar location fixes before deployment. We left activated collars in fixed locations for 3-4 days, occasionally agitating collars to avoid GPS system shut-off. We documented highly accurate stationary collar locations using a Trimble GeoXT GPS system (Trimble Navigation, Sunnyvale, CA). We considered fixes “high quality” if location points for stationary collars were within 30 m of each other in more than 95% of cases, and error of over 100 m occurred less than 1% of the time. The “2D” and “3D” location fixes from all Telonics collars were considered high quality and both types were used in analyses. Only the “3D” data from Televilt collars met these criteria and were analyzed.

## **Survival**

We asked whether puma mortality differed between the developed and undeveloped zones. We documented survival or mortality of each puma during the period of monitoring, beginning at capture and ending with the puma's last documented location. When collars transmitted mortality signals, we located the collar and investigated the cause of puma death or collar detachment. We calculated percent mortality during the study for all collared pumas as well as for pumas by zone, sex, and age class. We conducted two-sample independent Student's *t*-tests in JMP 5<sup>®</sup> statistical software (SAS Institute, Cary, N.C.) to determine whether pumas in each zone, sex, and age class were monitored for similar periods of time, allowing valid comparisons of mortality rates.

We used Pearson's chi-square tests to determine whether the proportion of pumas known to have died to pumas alive at the end of monitoring differed between puma zone, sex, or age classes. We recorded mortality and cause of death for pumas after collar drop-off through spring 2007, in the case that ear tag numbers on carcasses were reported to CDFG. We did not include puma deaths occurring after the expected date of collar retrieval in analyses, because developed-zone pumas often died due to depredation. These deaths were more likely to become known to us post-collar drop-off than were undeveloped-zone puma mortalities, which were less likely to result from depredation. To facilitate comparison of survival with other studies, we also calculated 12-month mortality rates, including only pumas that were monitored for at least one year, or died within their first 12 months of being monitored.

## **Dispersal**

We analyzed subadult dispersal patterns in combination with survival, to determine whether the population conformed to a habitat-limited structure, a source-sink structure, or an unfragmented population structure. We expected that a large proportion of subadults in a habitat-limited environment, such as that of the Florida panther (Maehr 2002), would disperse long summed distances or durations compared to other populations, possibly at relatively young ages, but fail to establish independent home ranges. We expected relatively short Euclidean dispersal distances for those animals successfully establishing home ranges, indicating a lack of available habitat elsewhere. This pattern could be represented by "frustrated dispersal" (Lidicker 1975), in which animals disperse long total distances, fail to find suitable habitat for a home range, and frequently return to their natal regions. In a source-sink population structure, we expected a large proportion of subadults to disperse and establish independent home ranges, but to experience high mortality or low chance of reproductive success in their new home ranges (Pulliam 1988). In an unfragmented structure, we expected dispersal frequency, establishment of independent home ranges, and survival rates to be similar to other puma populations in relatively undisturbed areas that were not heavily hunted.

We documented dispersal parameters for collared subadult animals that gained independence from their mothers during the study period. We used GPS collar locations from downloaded collars, as well as capture and mortality locations taken with handheld

Garmin<sup>®</sup> (Garmin Ltd.) GPS units. If we did not obtain a GPS collar download from a puma, we calculated dispersal parameters using locations obtained from collars' ARGOS uplink systems, aerial and ground VHF telemetry, or puma capture and recapture. We created databases and map layers containing locations for each puma in an ArcGIS 9.2<sup>®</sup> (ESRI Institute, Redlands, CA) Geographic Information System. The "point to polyline tool" in Hawth's Tools (Beyer 2004) extension for ArcGIS<sup>®</sup> was used to create linear paths between consecutive locations for each puma.

We documented puma age at capture ( $\pm 1$  month) and noted whether the animal was still traveling with its mother as indicated by capturing the mother or by analyzing tracks in the area. We determined age at independence ( $\pm 6$  weeks, inclusive) as the age when a puma stopped traveling with its mother as documented by track surveys or location data from collared mother and offspring. Age at dispersal ( $\pm 1$  month) was determined from collar location data and indicated by movements leaving and not re-entering a subadult puma's natal home range.

We used high-quality GPS collar locations to construct 95% kernel home ranges (Worton 1989) for each puma's pre-dispersal locations (natal home range) and post-dispersal locations (post-dispersal home range) with Hawth's Tools extension for ArcGIS<sup>®</sup>. We measured linear dispersal distance as the Euclidean distance in kilometers between the center of a puma's natal range and the center of the animal's post-dispersal home range, using the ArcGIS<sup>®</sup> measurement tool.

Because pumas sometimes changed dispersal directions, we also estimated the distance traveled during dispersal. We measured and summed the minimum Euclidean distance between location points taken 2 weeks apart for the duration of dispersal movements. Dispersal was considered to begin with the first location exiting and not returning to the natal home range, and to end when long-range ( $5^+$  km) directional movements ceased and pumas began to revisit territory within a new home range. We recorded the duration of dispersal (days), predominant direction of dispersal movements including major direction changes for each animal, and whether dispersal began from and terminated in the undeveloped or developed zone. We also documented whether each dispersal-aged puma died or lived to the end of the monitoring period, and cause of death.

### **Obstacles to movement**

We tested whether pumas avoided crossing rivers, highways, or residential housing developments in their home range areas to determine whether these features posed obstacles to puma movements, and compare the degree of obstacle posed by natural versus anthropogenic features. We used all high-quality locations from puma GPS collars that yielded data downloads to construct 95% kernel home ranges for each puma with Hawth's Tools "kernel density estimator" and "percent volume contour" functions. We created 1-km buffer zones surrounding each home range and merged these zones to the kernel home ranges, to create the "home range area" for each puma. The 1-km buffer, a small area relative to puma movement distances, allowed us to investigate possible obstacles affecting puma home range borders.

Using ArcGIS 9.2<sup>®</sup>, we created polyline shapefiles for major highways from USGS digital line graph road map layers, and for major rivers from USGS National Hydrography Dataset digital map layers. To identify residential housing developments, we joined county property parcel map layers from the counties inhabited by the collared pumas. We created a new polygon shapefile containing only residential parcels less than 2.0 acres (0.8 ha) in size, and used the merge tool to merge adjoining polygons smaller than 2 acres. Next, we selected only resultant polygons with maximum lengths >1 km to be investigated as potential puma movement obstacles and created a new “residential development” shapefile from this selection.

Because highways, major rivers, and residential areas sometimes occurred in association with each other, we removed the portions of these layers that overlapped or nearly overlapped, and only analyzed potential obstacles in areas where they did not coincide with the other 2 features. For each potential obstacle feature we created a 300-m buffer zone, and selected only areas of that feature and its buffer that did not intersect a different potential obstacle. We created new shapefiles of highways, rivers and residential developments that were not immediately proximate to another potential obstacle feature. We added 300-m buffer zones on either side of the non-overlapping highway and river features.

Puma data files were filtered to include only locations that occurred at a 6-hour interval from the next location. We did not include subadult female 901 in these analyses due to lack of location points. We used a query to create files of locations for each puma that occurred in highway, river and residential development buffer zones. We included only locations on the side of the potential obstacle containing most of the puma’s ranging area, to determine whether pumas were crossing features from one side to the other. Because residential development polygons had several sides, we manually removed the small number of puma locations occurring opposite the long side of the polygon proximate to the larger portion of a puma’s home range area.

We used the Hawth’s Tools’ “point to polyline tool” to connect all successive points in a puma’s location file in linear paths. Unique paths were constructed for each set of consecutive 6-hour interval fixes. For each puma we recorded the number of generated puma paths that crossed rivers, highways, and residential development. We then determined the expected frequency of potential obstacle feature crossings for each puma, based on the animal’s movement data. Hawth’s Tools “calculate animal movement parameters” tool was used to generate a list of distances (steplength) and turn angles between all successive 6-hr interval locations in each puma’s GPS collar dataset. We filtered non-successive location points from these tables. We calculated the likelihood of feature crossings within 6 hours for each puma location point that occurred in the highway, river or development buffer, on the side of most of the animal’s home range area. For each puma, we used Hawth’s Tools’ “conditional point sampling tool”, to generate 1000 points around each collar location occurring in a potential obstacle buffer zone. The tool allowed us to base the 1000 generated point locations on sampling from

the steplength and turnangle distributions for the given puma. We, thus, created predictions of the puma's expected next movement based on its own movement data.

We created a large (5000 m) buffer to display areas opposite the potential obstacle from the puma location points analyzed. The "intersect point tool" was used to generate a count of the number of newly generated points that fell within this zone, indicating an expected crossing of the obstacle feature. We calculated the percentage of all generated points that lay across potential obstacles to determine the expected probability of each puma crossing each feature. Paired Student's t-tests were used in JMP 5<sup>®</sup>, to compare the percent of expected crossings to the percent of observed crossings of each highway, river, and residential development for all pumas, to determine whether pumas avoided crossing these features. We used a query to calculate the percentage of puma paths crossing a highway that occurred within a 300-m buffer area of a creek or river that passed beneath the roadway, to investigate whether pumas may have crossed using these underpasses. We also noted whether we saw puma sign in these riparian underpasses during tracking.

### **Parcel size use**

For developed-zone pumas, we asked whether the animals preferentially used or avoided property parcel size classes in their home range areas representative of various types of rural development including ranches, ranchettes, and suburban style housing development. For each developed-zone puma's GPS collar dataset, we used Hawth's "intersect point tool" in ArcGIS 9.2<sup>®</sup> to generate a data field displaying the areas (acres) of all property parcels containing a puma location point. Because smaller parcel size classes tended to be located in groups of like-sized parcels, the small spatial error associated with GPS collar locations was not expected to cause an underestimate of puma use of small parcel size classes. We calculated the percentage of each puma's locations occurring in each of 6 parcel size classes, chosen for relevance to development planning designations: 0.10 to 5.00 acres (0.04 to 2.02 ha), 5.01 to 10.00 acres (2.03 to 4.05 ha), 10.01 to 20.00 acres (4.05 to 8.09 ha), 20.01 to 40.00 acres (8.10 ha to 16.19 ha), 40.01 to 100.00 acres (16.19 to 40.47 ha), and 100<sup>+</sup> acres (40.47<sup>+</sup> ha).

We next estimated the spatial coverage of each parcel size class within each puma's home range area. We used Hawth's Tools' "generate random points" function to create random points within the polygons of each puma's home range area, equal to the number of high-quality location points obtained for each puma. We used "home range areas", which included a 1-km buffer around each animal's 95% kernel home range, to include areas that pumas might avoid, which we wished to identify. For each home range area, we documented the property parcel sizes associated with each randomly generated point using the "intersect point tool", and calculated the percentages of random points falling within each parcel size class. Paired Student's t-tests were used in JMP 5<sup>®</sup> to test for differences between use of each parcel size class by pumas and the spatial coverage of those parcel classes in home range areas.

We then asked whether puma use of parcel classes differed between day and nighttime. We designated all location points occurring between 09:00 hrs and 17:00 hrs PST as

daytime locations, and all points occurring between 21:00 hrs and 05:00 hrs PST as nighttime locations. Day and night location files were created for each puma, including the parcel sizes associated with each location point. We calculated the percentage of locations in each of the 6 parcel size classes for the day and nighttime locations of each puma. Paired Student's t-tests were used in JMP 5<sup>®</sup> to identify diel differences in puma use of the parcel size classes.

## **Results**

### **GPS collars and capture**

We deployed GPS collars on 19 pumas during 2002-2005, with one animal collared twice. Pumas were tracked by collar during 2002-2006. Fourteen of these collars yielded successful downloads, representing all data collected by GPS collars on 13 individuals. Table 1 displays: age class, sex, development zone, collar type, number of location fixes used in analyses, fix interval, duration of data for each puma, and mortality occurrence and cause of death. We used only high-quality fixes in analyses for pumas from which collar downloads were obtained. Pumas whose GPS collars failed were only included in survival and dispersal analyses, using ARGOS-transmitted GPS collar locations, aerial and ground VHF locations, and capture and carcass locations (Table 1).

We collared 4 adult male pumas, 4 subadult males, 1 juvenile male (pre-independence), 7 adult females, and 3 subadult females. Nine collared pumas occupied the developed zone while 10 of the animals lived in the undeveloped zone. Subadult pumas collared in the undeveloped zone that moved to developing rural areas after independence were classified as developed zone pumas. Developed zone pumas lived in a mosaic of ranches, ranchettes, public lands and residential developments networked by highways. Undeveloped zone pumas occupied a mix of national forest and private timberlands with few or no residential properties.

### **Survival**

Table 1 displays the number of days that each puma was monitored from first observation (usually capture date) through the animal's last documented location. Survival or mortality at the end of each animal's monitoring period is noted, as well as cause of death.

Six of 9 pumas (66.7%) collared in the developed zone were known to have died between 10 weeks and 26 months after capture, while 1 of 10 pumas (10%) died in the developed zone, 10 months post-capture. Because the death of subadult female 901 was documented long after collar retrieval (26 months post-capture), we included in analyses only the 10-month period during which this female was tracked by collar, in order to compare survival between groups monitored for comparable periods. Pumas were monitored for a mean 296 days with standard deviation of 164 days. Two-sample independent Student's t-tests found the number of days pumas were monitored did not differ between sexes ( $t = 1.300$ ,  $df = 17$ ,  $p = 0.212$ ), ages ( $t = 0.078$ ,  $df = 17$ ,  $p = 0.939$ ), development zone ( $t = 0.088$ ,  $df = 17$ ,  $p = 0.931$ ) or for animals documented to have survived versus those that

**Table 1.** Collar performance, time monitored by collar, and puma fates by development zone, for GPS-collared pumas in California's Western Sierra Nevada, 2002-2007. TA = Telonics Argos collar. TP = Televilt PosRec Collar. Puma ID: S = Subadult, A = Adult, J = Juvenile; M = Male, F = Female.

Puma ID	Collar type	No. High quality fixes	Fix interval (hrs)	Days monitored by collar	Mortality	Cause of death
Exurban zone						
SM119	TA	1197	3	211	Y	puma
SM130	TA	2055	3	478	N	
SM170	TA	72 <sup>1</sup>	NA	236	N	
AF200	TA	1114	3	454	Y	depredation
AF797	TP	445	2	224	N	
AM852a	TP	1240	1	68	Y	depredation
SM852b	TP	1131	2	171	Y	vehicle
SF889	TP	22 <sup>2</sup>	NA	521	Y	depredation
SF901	TP	146	12	270	Y <sup>4</sup>	depredation
Undeveloped zone						
AM110	TA	7 <sup>1</sup>	NA	172	N	
JM150	TA	484	3	95	N	
AM160	TA	1521	3	286	Y	unknown
AF180	TA	3014	3	677	N	
AM190	TA	2285	3	492	N	
AF809	TP	163	2	317	N	
AF819	TP	830	2	230	N	
AF838	TP	12 <sup>1</sup>	NA	82	N	
AF868/ 829 <sup>3</sup>	TP	2596	2, 1	355	N	
SF881	TP	34 <sup>1</sup>	NA	288	N	

<sup>1</sup>Argos uplink, aerial, and ground locations only; no GPS collar download.

<sup>2</sup>Aerial and ground locations only; no GPS collar download.

<sup>3</sup>Adult female collared twice consecutively.

<sup>4</sup>Puma killed 16 mos. after collar detachment, mortality not used in analyses.

died ( $t = 0.273$ ,  $df = 17$ ,  $p = 0.788$ ). Thus, we were able to compare puma mortality proportions between groups using fates documented within the periods that animals were monitored.

Table 2 displays the mean percent mortality for each puma group within the time of monitoring, excluding the death of SF901, 26 months post-capture. Developed-zone pumas were more likely to die (55.6%) than undeveloped-zone pumas (10%;  $\chi^2 = 4.550$ ,  $p = 0.033$ ). Mortality rates did not differ between males and females ( $\chi^2 = 1.310$ ,  $p = 0.252$ ) or between subadult and adult pumas ( $\chi^2 = 0.224$ ,  $p = 0.636$ ).

We also calculated 12-month puma mortality rates including only pumas that were tracked for a year or more, or died within the first 12 months of being monitored (Table 2). Overall, 30.8% of pumas (4 of 13) died within a year of collaring. Adult mortality was 25.0% (2 of 8), while 40.0% (2 of 5) of subadults died. All pumas killed within their first 12 months of being monitored were male, and 3 of 4 occupied the developed zone. The developed zone 12-month mortality rate was 42.9% (3 of 7) and the undeveloped zone rate was 16.7% (1 of 6).

**Table 2.** Mortality of GPS-collared pumas by group during time of monitoring, and during first 12 months of monitoring, in California’s Western Sierra Nevada, 2002-2006.

Puma Group	Total mortality		12-month mortality	
	n	%	n	%
All	19	31.6	13	30.8
Developed Zone	9	55.6*	7	42.9
Undeveloped Zone	10	10.0*	6	16.7
Male	9	44.4	7	57.1
Female	10	20.0	6	0.0
Adult	11	27.3	8	25.0
Subadult	8	37.5	5	40.0

\*Pearson’s chi-square test indicates mortality difference between groups,  $\alpha = 0.05$ . Adult male AM160 was the only undeveloped-zone puma that died while tracked by collar. The body was intact but cause was unknown. GPS collar data indicated AM160 and adult male AM190 were proximate to each other for several hours 14 days before AM160’s death, after which AM160’s movements shortened, but no recent external wounds were apparent.

In the developed zone, tracks and wounds indicated subadult male SM119 was killed by an adult male puma, 7 months after collaring. SM119 was in thin, poor condition when killed. Subadult male 852b was killed on a busy multi-lane highway, 6 months after capture. AM852a, a 4-year old adult male, was killed due to depredation on sheep 10 weeks after capture. Adult female AF200 was killed 16 months post-capture due to

depredation on goats newly introduced to a large ranch. Developed-zone subadult females, SM901 and SM889, were collared as dependent juveniles, and both were killed post-independence for depredation on Barbados sheep on ranchette properties. Subadult female SF889 was in thin, poor condition at time of death.

### Dispersal

Five subadult animals were collared as dependent juveniles, and an additional subadult was collared while already dispersing, at  $13 \pm 1$  months old. Dispersal parameter values are displayed in Table 3, including number of dispersal location fixes; minimum age of independence; age of dispersal; duration of dispersal movements; linear distance dispersed; summed distance traveled, direction moved; natal zone; zone where dispersal was completed; and puma fate. The collar of subadult female SF889 failed prior to independence from its collared mother, with only carcass location indicating dispersal, and age of independence and dispersal unknown.

**Table 3.** Dispersal parameters for GPS-collared subadult pumas in California's Western Sierra Nevada, 2002-2006. Puma ID: S = subadult, M = male, F = female. Zone: U = undeveloped, D = Developed. NA = Not applicable, puma did not disperse.

Dispersal Parameter	SM119	SM130	SM170	SF881	SF889	SF901
Age of independence (mos, $\pm 6$ wks)	13 <sup>1</sup>	12	12	12	unknown	11
Age at dispersal (mos, $\pm 1$ month)	13	14	14	13	unknown	NA
Dispersal period (days)	108	124	147 <sup>2</sup>	56	unknown	NA
Euclidean distance dispersed (km)	23.2	38.4	141.1	27.2	16.2	0
Summed distance traveled (km)	138.7	86.3	194.0	31.5	unknown	0
Movement direction	SW, N	SW	SW, SE	SSE	W	NA
Natal zone	U	U	U	U	U	D
Dispersal zone	D	D	D	D	D	D
Mortality: reason	Y: puma	N	N	N	Y: depredation	Y: depredation

<sup>1</sup>Puma already independent when captured at 13 mos. of age.

<sup>2</sup>Collar failed during dispersal.

All pumas gained independence between 11 and 13 months of age, with a mean of 12 months ( $n = 5$ , margin of error 1.5 months). Five of 6 independence-aged animals dispersed, including all 3 males and 2 of 3 females. Documented dispersal age for 4 subadults ranged from 13 to 14 months with a mean of 13.5 months (margin of error 1 month). Dispersal movements were documented to proceed for a minimum of 56 to a

maximum of 147 days, although the male that moved for 147 days was still dispersing when its collar signal was lost. Collar locations indicated that sibling males SM170 and SM130 associated during dispersal for  $42 \pm 7$  days.

All 5 pumas that dispersed were collared in undeveloped-zone natal ranges, and all but one female dispersed into the developed zone. The only puma that remained philopatric with its mother was female SF901, the only puma collared in a developed zone natal range. The 3 dispersing males all initially moved southwest, toward lower elevations and developed areas, although 2 eventually changed direction. The female that remained in the undeveloped zone dispersed south-southeast. Female SF889, from which only pre- and post-dispersal locations are known, moved west overall from the undeveloped zone to the developed zone.

Collar-location data indicated that all dispersing animals crossed the home ranges of other collared pumas, and dispersal paths traversed all major sectors of the study area. All dispersing males crossed major highways, rivers and rural residential areas, and traveled from 86.3 to 194.0 km, measured as the sum of linear distances traveled every two weeks during dispersal. Males dispersed Euclidean distances 23.2 km to 141.1 km ( $\mu = 67.6$  km) away from their natal ranges. Female subadult SF881 traveled 31.5 km summed distance, and dispersed 27.2 km Euclidean distance from its natal range, while female SF889 dispersed 16.2 km Euclidean distance from its natal range.

Male SM170 moved more than 80 km into the Auburn city limits, then across more than one hundred kilometers of rugged, mountainous terrain before collar signal cessation. Male SM119 briefly occupied a commercial area of the city of Placerville, before moving north to establish a long, narrow home range straddling multi-lane highway I-80, and being killed by another puma. Additionally, independent subadult male SM852b had already occupied a long, narrow home range stretched along highway I-50, at the time of collaring. SM852b was killed by a vehicle on the highway. Overall, 57.1% of the subadult animals (4 of 7) were known to have died during our study, all in the developed zone. Two of these were in thin, poor condition at time of death.

### **Obstacles to movement**

Table 4 displays the expected and observed percentages of puma paths generated from GPS-collar location points that crossed highways, rivers, and dense residential developments. Highways occurred in the home range areas of all 6 developed-zone pumas and 4 of 6 undeveloped-zone pumas, for which collar downloads were obtained. Three developed-zone puma home range areas and all undeveloped-zone home range areas contained major rivers. Dense residential developments occurred in the home range areas of 5 developed zone pumas and 1 undeveloped-zone puma.

Pumas crossed potential obstacle features far less often than predicted from paths generated using that animal's movement data. Paired t-tests indicated that pumas crossed highways ( $t = 50.661$ ,  $df = 9$ ,  $p < 0.001$ ), rivers ( $t = 11.873$ ,  $df = 7$ ,  $p < 0.001$ ), and residential developments ( $t = 7.612$ ,  $df = 5$ ,  $p < 0.001$ ) significantly less than expected.

Paths derived from puma movement patterns predicted that pumas would cross highways 785% more often, rivers 430% more often, and dense residential developments, 373% more often than was documented. A large majority (86.8%) of puma paths that crossed highways were within 300 m of creeks or rivers and associated highway bridges, and we occasionally noted puma tracks passing beneath these bridges.

**Table 4.** Percent puma paths crossing potential obstacles in California’s Western Sierra Nevada; projected from GPS collar data 2002-2006. Puma ID: S = subadult, A = adult, J = juvenile, M = male, F = female. Expected crossings calculated as the percentage of 1000 points randomly generated using each puma’s movement parameter distribution, situated across the potential obstacle from an actual puma location point within a highway, river, or residential area buffer zone.

Puma ID	% Highway crossings		% River crossings		% Residential area crossings	
	Expected	Observed	Expected	Observed	Expected	Observed
<b>Exurban Zone</b>						
SM119	37.1	7.6	36.1	3.3	32.9	16.4
SM130	31.0	4.5	31.8	5.8	28.6	3.9
AM852a	31.3	0.0	31.8	0.0	27.0	9.6
SM852b	29.8	0.2	NA	NA	NA	NA
AF200	30.7	3.4	NA	NA	24.2	7.2
AF797	31.8	5.1	NA	NA	26.7	8.5
<b>Undeveloped Zone</b>						
JM150	33.5	3.7	32.2	11.4	NA	NA
AM160	36.8	7.3	36.7	12.6	NA	NA
AM190	40.0	10.0	41.1	14.1	34.9	1.1
AF180	26.2	0.0	NA	NA	NA	NA
AF819	NA	NA	30.6	16.0	NA	NA
AF868	NA	NA	31.3	0.0	NA	NA
Mean % difference expected/observed		785.2*		429.7*		373.2*

\*Difference between observed and expected values for all pumas pooled using paired Student’s t-test,  $\alpha = 0.05$ .

### Parcel size use

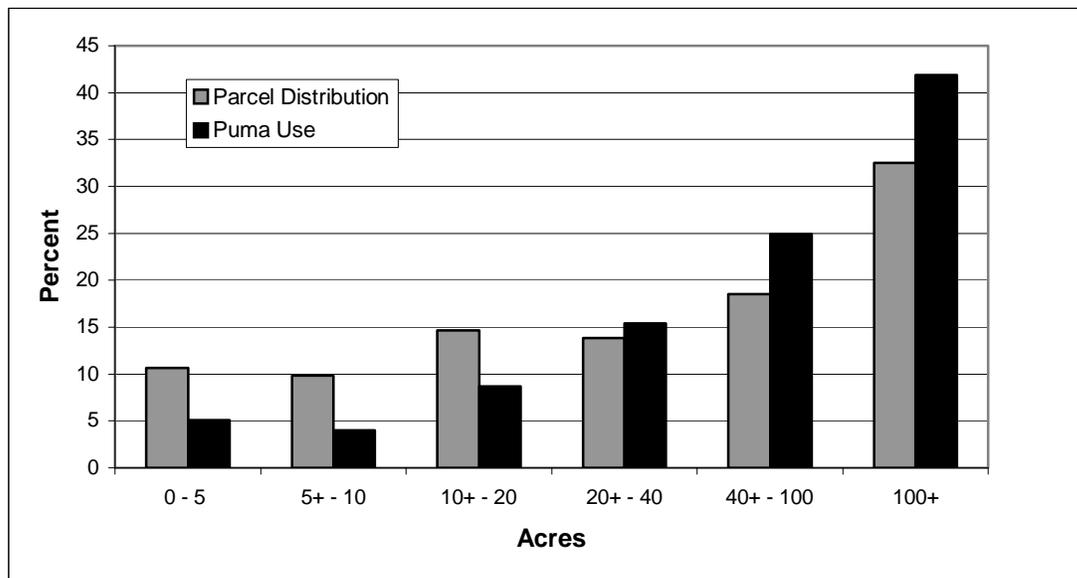
For developed-zone animals, Table 5 and Fig. 2 display the percentage of puma locations by property parcel size class, versus the percent land coverage of those parcel classes in the animals’ home range areas. Paired t-tests indicated that pumas used the smaller parcel size classes of 0.10 to 5.00 acres (0.04 to 2.02 ha), 5.01 to 10.00 acres (2.03 to 4.05 ha), and 10.01 to 20.00 acres (4.05 to 8.09 ha), less than the land coverage of those parcel classes in the pumas’ home range areas ( $t = 3.688$ ,  $df = 5$ ,  $p = 0.014$ ;  $t = 4.466$ ,  $df = 5$ ,  $p = 0.006$ ;  $t = 2.612$ ,  $df = 5$ ,  $p = 0.048$ ). Puma use of the 20.01- to 40.00-acre (8.10- to 16.19-ha) parcel class did not differ from the spatial coverage of this class in the animals’ home

range areas ( $t = 1.216$ ,  $df = 5$ ,  $p = 0.278$ ). The larger parcel size classes, 40.01 to 100.00 acres (16.19 to 40.47 ha) and 100.00<sup>+</sup> acres (40.47<sup>+</sup> ha), contained a greater percentage of puma locations than the representation of these parcels in puma home range areas ( $t = 2.603$ ,  $df = 5$ ,  $p = 0.048$ ;  $t = 2.766$ ,  $df = 5$ ,  $p = 0.040$ ).

**Table 5.** Actual vs. expected percent use of property parcel size classes by GPS-collared pumas in developed rural zone of California’s Western Sierra Nevada, 2002-2006. Values presented as actual/expected use. Actual use: percent puma collar location points in parcel size class. Expected use: percent land coverage of each parcel size class in puma’s home range area.

Puma ID	0.10-5.00 acres	5.01-10.00 acres	10.01-20.00 acres	20.01-40.00 acres	40.01-100.00 acres	100.00+ acres
SM119	15.7/18.0	7.7/8.1	12.1/9.4	11.2/11.5	18.7/16.2	34.7/37.0
SM130	0.0/9.2	0.0/6.2	5.6/18.5	11.1/13.9	33.3/24.6	50.0/27.7
AF200	1.7/12.5	4.6/10.3	8.0/12.5	15.5/12.9	23.2/18.6	47.1/33.3
AF797	4.6/7.3	5.0/12.0	10.8/15.3	16.4/13.8	20.7/16.3	42.4/35.5
AM852a	1.8/7.6	1.3/11.6	5.9/17.3	17.3/16.5	32.6/15.1	41.1/31.9
SF901	6.9/9.5	5.6/11.0	9.7/15.0	20.8/14.5	21.1/20.3	35.8/29.8
Mean	5.1/10.7*	4.0/9.9*	8.7/14.7*	15.4/13.9	24.9/18.5*	41.9/32.5*

\*Difference between mean actual and mean expected use of parcel size class, using paired Students t-test,  $\alpha = 0.05$ .



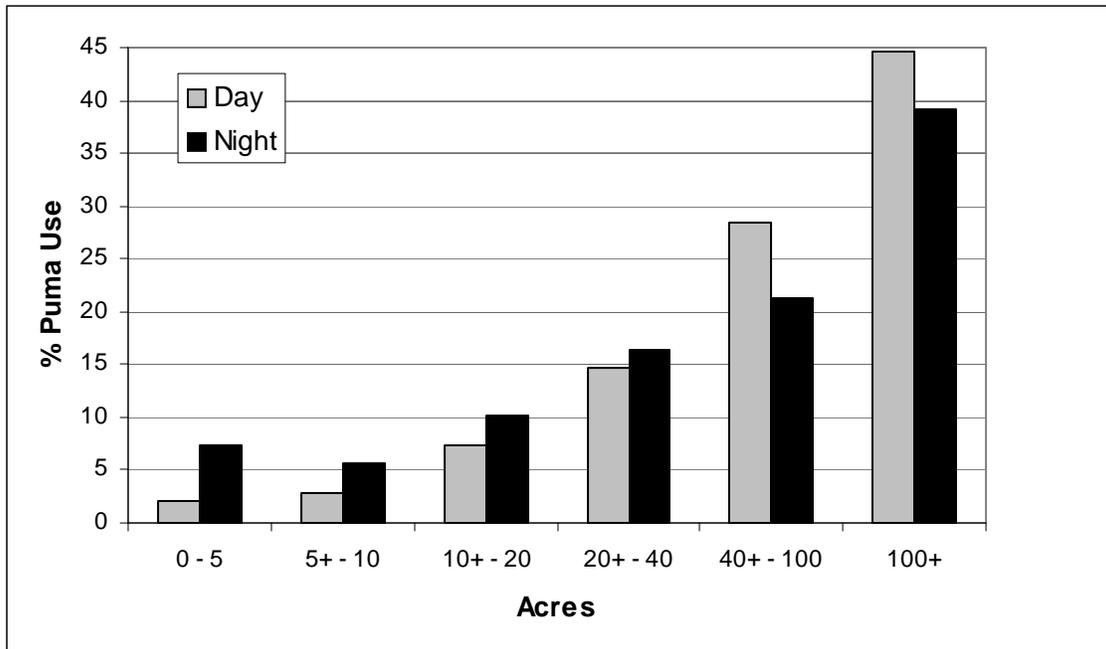
**Figure 2.** Percent puma use by property parcel size class vs. percent land coverage of parcel size classes in puma home range areas (95% kernel home range and 1 km buffer), for GPS collared pumas in developed rural zone of California’s Western Sierra Nevada, 2002-2006.

Table 6 and Fig. 3 display the percentage of puma locations in each parcel size class for daytime versus nighttime locations. Paired Student's t-tests indicated that nighttime puma locations (21:00 hrs to 05:00 hrs PST) occurred more often in the smaller parcel size classes, 0 to 5.00 acres, 5.01 to 10.00 acres, and 10.01 to 20.00 acres, than did daytime locations (09:00 hrs to 17:00 hrs PST) ( $t = 2.657$ ,  $df = 5$ ,  $p = 0.045$ ;  $t = 3.719$ ,  $df = 5$ ,  $p = 0.014$ ;  $t = 4.604$ ,  $df = 5$ ,  $p = 0.006$ ). Nighttime locations occurred less often in the 2 largest parcel size classes, 40.01 to 100.00 acres and 100.00<sup>+</sup> acres, than did daytime puma locations ( $t = 6.482$ ,  $df = 5$ ,  $p = 0.001$ ;  $t = 4.795$ ,  $df = 5$ ,  $p = 0.005$ ). Puma use of 20.01- to 40.00-acre parcels did not differ between day and night ( $t = 1.387$ ,  $df = 5$ ,  $p = 0.224$ ).

**Table 6.** Percent day vs. night use of property parcel size classes by GPS-collared pumas in developed rural zone of California's Western Sierra Nevada, 2002-2006. Values presented as percent day/percent night use. Day use: percent puma collar locations in parcel size class during 09:00 hrs -17:00 hrs. Night use: percent puma collar locations in parcel size class during 21:00 hrs -05:00 hrs.

Puma ID	0.10-5.00 acres	5.01-10.00 acres	10.01-20.00 acres	20.01-40.00 acres	40.01-100.00 acres	100.00+ acres
SM119	6.9/20.8	5.3/9.0	10.9/13.2	13.0/10.1	23.3/16.9	40.5/29.7
SM130	0.0/0.0	0.0/0.0	4.4/8.9	9.7/12.9	34.8/30.7	51.1/47.6
AF200	0.5/3.3	2.9/7.1	6.4/9.7	15.7/15.1	25.7/20.9	48.8/44.0
AF797	2.2/7.1	3.0/7.8	10.0/11.2	15.4/16.8	23.9/16.8	45.2/40.1
AM852a	0.2/3.1	1.0/2.2	3.1/7.8	15.7/20.3	37.1/26.8	43.0/39.9
SF901	2.8/9.8	4.4/7.4	9.1/10.4	18.5/23.0	26.2/15.6	38.8/33.5
Mean	2.1/7.4*	2.8/5.6*	7.3/10.2*	14.7/16.4	28.5/21.3*	44.6/39.1*

\*Difference between mean daytime and mean nighttime use of parcel size class, paired Students *t*-test,  $\alpha = 0.05$ .



**Figure 3.** Percent use by property parcel size class, day vs. night, for GPS collared pumas in rural developed zone of California’s Western Sierra Nevada, 2002-2006.

## Discussion

We found evidence that low-density rural development, with associated highways and dense housing developments, resulted in fragmented puma habitat. Our results were consistent with attributes of a source-sink population structure, disrupted connectivity of landscapes for pumas, and the creation of habitat patches that pumas avoided in their developed-zone home range areas.

Survival and dispersal parameters were obtained from a small sample, but were consistent with a source-sink population and differed from our expectations for a habitat-limited, or an unfragmented population structure. The 12-month mortality rate for all pumas in our sample, 31%, was greater than annual mortality rates from un hunted populations in other western states of 12% to 28% (Lindzey et al. 1988, Anderson et al. 1992, Beier and Barrett 1993, Logan and Sweanor 2001). Mortality for the Western Sierra pumas was comparable to the higher mortality figures from hunted puma populations, reported as 27%, 0% to 27%, and 32% (Ashman et al. 1983, Robinette et al. 1997). Our subadult puma 12-month mortality rate, 40%, was also considerably greater than the 24% annual mortality rate reported from an expanding population in New Mexico (Sweanor et al. 2000), and the 26% rate from a habitat-limited population in Florida (Maehr et al. 2002).

However, 12-month mortality in the undeveloped zone, 16.7%, was among the lowest reported in the literature, while the 42.9% mortality rate in the developed zone exceeded

even mortality from a heavily exploited puma population in Arizona, in which pumas were removed for depredation control (Cunningham et al. 2001). Cunningham et al. (2001) contended that their study population, with a 38% mortality rate, represented a demographic sink. Jalkotzy et al. (1992) projected that a puma population could sustain an overall mortality rate of about 15%, of which 5% would be from natural causes. Further, 3 of 4 collared females in the developed zone died within 26 months of collar deployment, all at breeding age. High levels of mortality among breeding-aged females can significantly impact large carnivore population viability (Lindzey et al. 1992, Gittleman 1993).

If the puma population were habitat-limited, we expected frequent failure of dispersing subadults to establish independent home ranges; long summed dispersal distances and durations compared to other populations, but short Euclidean dispersal distances for animals that eventually established home ranges; and potentially, young ages of independence and dispersal. In contrast, all dispersing subadults successfully established home ranges, except SM170 whose outcome was not known. Age of independence of juvenile pumas ( $\mu = 12 \pm 1.5$  months) was low compared to mean ranges from other studies ( $13.7 \pm 1.6$  months, Sweanor et al. 2000;  $15.2 \pm 3.0$  months, Ross and Jalkotzy 1992). Mean dispersal age,  $13.5 \pm 1$  months, was less than the means of  $15.2 \pm 1.6$  months, 16.0 months,  $17.9 \pm 4$  months,  $18.0 \pm 2.8$  months, and 16-19 months, reported from pumas in other North American populations (Sweanor et al. 2000, Ross and Jalkotzy 1992, Maehr et al. 1991, Beier 1995, Hemker et al. 1984).

The sample of puma dispersal distances suggested that habitats containing adequate food resources, or at least, that were free of competitive adult males, were sometimes available to pumas in developed areas near the undeveloped zone. Euclidean dispersal distances ( $23-142^+$  km for males and 16-27 km for females) appeared similar to or less than dispersal distances documented in other populations (Sweanor et al. 2000: 67-176 km, males, 2-96 km, females; Anderson et al. 1992: 29-247 km, males, 9-140 km, females; Ross and Jalkotzy 1992: 30-155 km, all pumas). Mean Euclidean dispersal distance for habitat-limited Florida panthers eventually establishing home ranges was only 37 km for males, and 11 km for females (Maehr et al., 2002). The summed dispersal distances (86.3-194.0 km males, 31.5 km female) of our sampled subadults were not particularly long compared to Euclidean distances, in contrast to a frustrated dispersal model (Lidicker 1975). Duration of dispersal ( $1.9-4.9^+$  months) was far less than for Florida panthers (7.0 months for females, 9.6 months for males, Maehr et al., 2002).

In an unfragmented population structure, we expected occurrence of dispersal, establishment of independent home ranges, and survival rates to be similar to puma populations in relatively undisturbed areas that were not heavily hunted. Survival rates, notably in the developed zone, were considerably lower than in other puma populations, including hunted populations. Like in unfragmented populations, all subadult males dispersed and most or all established independent home ranges (Seidensticker et al. 1973, Hemker et al. 1984, Anderson et al. 1992, Ross and Jalkotzy 1992). Two of 3 subadult females dispersed, including both those collared in the undeveloped zone, although female dispersal typically appears rare (Laing and Lindzey 1993, Sweanor 2000). Logan

and Sweanor et al. (2001) postulated that female puma dispersal, unlike male dispersal, is partly density dependent and is driven by a shortage of per capita food resources in a puma's natal region.

Consistent with expectations for a source-sink population structure, most subadults dispersed and established home ranges, but experienced high mortality in their new home ranges (Pulliam 1988). Notably, 4 of 5 dispersers moved from undeveloped-zone natal ranges, ostensibly a demographic source area, into the developed zone, potentially a sink area. The only subadult failing to disperse was the only animal with a natal range in the developed zone. Instead of constituting a true sink, some or all of the developed zone could also have functioned as a "pseudo-sink" (Watkinson and Sutherland 1995), an area able to independently sustain a small population but where high immigration raises the number of individuals beyond that which the area can support.

The developed zone may have offered habitat availability due to sufficient resources coupled with a high turnover of pumas driven by high mortality. However, 2 of 4 developed zone subadults died in poor, thin condition. Young pumas trying to obtain food and gain adequate hunting skills while avoiding interactions with adult males, often the main cause of puma mortality in un hunted populations (Logan and Sweanor 2001), may effectively have been pushed into marginal urban interface habitats. For example, two subadult males established long, narrow home ranges along major highways before their deaths. The male portion of this population may conform to Pulliam and Danielson's (1991) "ideal preemptive distribution", in which young, subordinate animals move from a high-quality source area into a low-quality sink until they are ready to challenge older males occupying source areas. In contrast, young pumas in particular could have been attracted to these interface areas by the presence of roadkill, suburban deer, or domestic animals, which may have been relatively easy to obtain.

Highway and housing construction threatened to fragment puma habitat by disrupting landscape connectivity for pumas. Animals crossed highways in their home range areas 7.9 times less than expected, when the pumas were within 300 m of the road. Puma home ranges tended to border rather than include highways. Pumas crossed 4- to 8-lane highways rarely, likely by passing under bridges along riparian areas, and one puma was killed crossing a highway. Highways  $\geq 6$  lanes have been documented to seriously fragment puma populations and cause significant mortality (Beier and Barrett 1993, Beier 1995, Logan and Sweanor 2001). Increasing traffic or further highway expansion could increase mortality and disconnect puma habitats in our region. Housing developments (parcels  $\leq 2$  acres (0.8 ha)) disrupted puma movements similar to the effects of major rivers, with pumas crossing both features about four times less than expected. Dense housing developments not only threaten to increase human-caused puma mortality, but may degrade landscape connectivity. Noss et al. (1996) contended that for large carnivores, connectivity mainly involves circumventing barriers such as highways and developed areas, and minimizing human causes of mortality.

Subdivision of property parcels to 20 acres or less decreased pumas use of these parcels within their home range areas, and created patches of preferred ( $\geq 40$ -acre (16.2-ha)

parcels) and non-preferred habitat ( $\leq 20$ -acre (8.1-ha) parcels). Patterns of habitat avoidance and preference by parcel size were similar for all developed-zone pumas sampled, with each animal using the 20<sup>+</sup>-to 40-acre size class in a neutral manner. Yet these mid-sized parcels also presented heightened mortality risks from human-caused sources such as vehicle collisions or removal following depredation on pets and livestock. Orlando et al. (2008a) found depredations, the primary cause of puma death in our study, to occur on a mean property parcel size of 48.7 acres (18.9 ha), and median parcel size of 18.0 acres (7.3 ha) in the Western Sierra study area. All pumas preferred  $\geq 40$ -acre parcels more strongly during the day, and avoided  $\leq 20$ -acre parcels more strongly during the day. Pumas may have been avoiding use of human-dominated environments during times of high human activity, but still relying partly on these areas for hunting.

### **Management Implications**

Rural development created preferred and non-preferred/high-risk habitat patches at the individual level (third-order selection (Aebischer et al. 1993); disrupted functional connectivity at the landscape level; and created a source-sink or source-pseudo-sink condition at the population level for pumas. Source-sink population structures are not necessarily unsustainable or uncommon among wide-ranging large carnivores (Howe et al. 1991, Dias 1999, Noss et al. 1996, Pulliam 1988). Howe et al. (1991) found that a large but finite proportion of a metapopulation can exist in non-sustaining subpopulations, and these demographic sinks may connect source populations, aiding overall viability. In a source-sink or -pseudo-sink condition, protection of large demographic source areas, interconnectedness between sources, and protection of buffer areas supporting sink populations is vital to maintain long-term viability (Hansson 1991, Howe et al. 1991, Roberts 1998). The status of population subunits must be carefully monitored. Thus, conservation of the study population mandates concern regarding housing and highway expansion as a threat to source-area connectivity, and residential development as a threat to puma habitat utility in buffer and source areas.

Most undeveloped foothill land in our study region is already slated for residential development in parcel sizes of 40 acres or less (Strahlberg and Williams 2002, Stoms 2004, Walker et al. 2003). Although the higher elevation undeveloped zone of the Western Sierra may continue to support pumas, this zone spanned only about 1.4 times the average home range width of an adult male puma in our study population (Orlando et al. 2008b). We expect further foothill development to constrict remaining source areas, threaten connectivity, degrade marginal area habitats for pumas, and result in an overall decline in numbers of pumas.

To conserve pumas and associated biodiversity, source areas, in our case the undeveloped national forests and timberlands of the Western Sierra, should be managed for low or no puma harvest, light exploitation of ungulate populations, minimum potential for livestock conflict, and few opportunities for human-puma conflict (Cougar Management Guidelines 2005). Rural developed areas in puma habitat should be managed as buffer zones for source areas. State and county planning should aim to limit habitat

fragmentation from major road development or expansion, and maintain habitat linkages and property parcel sizes greater than 40 acres. Measures to limit human-caused mortality are essential, including educating residents on depredation threats and prevention, and providing highway underpasses along wildlife movement corridors.

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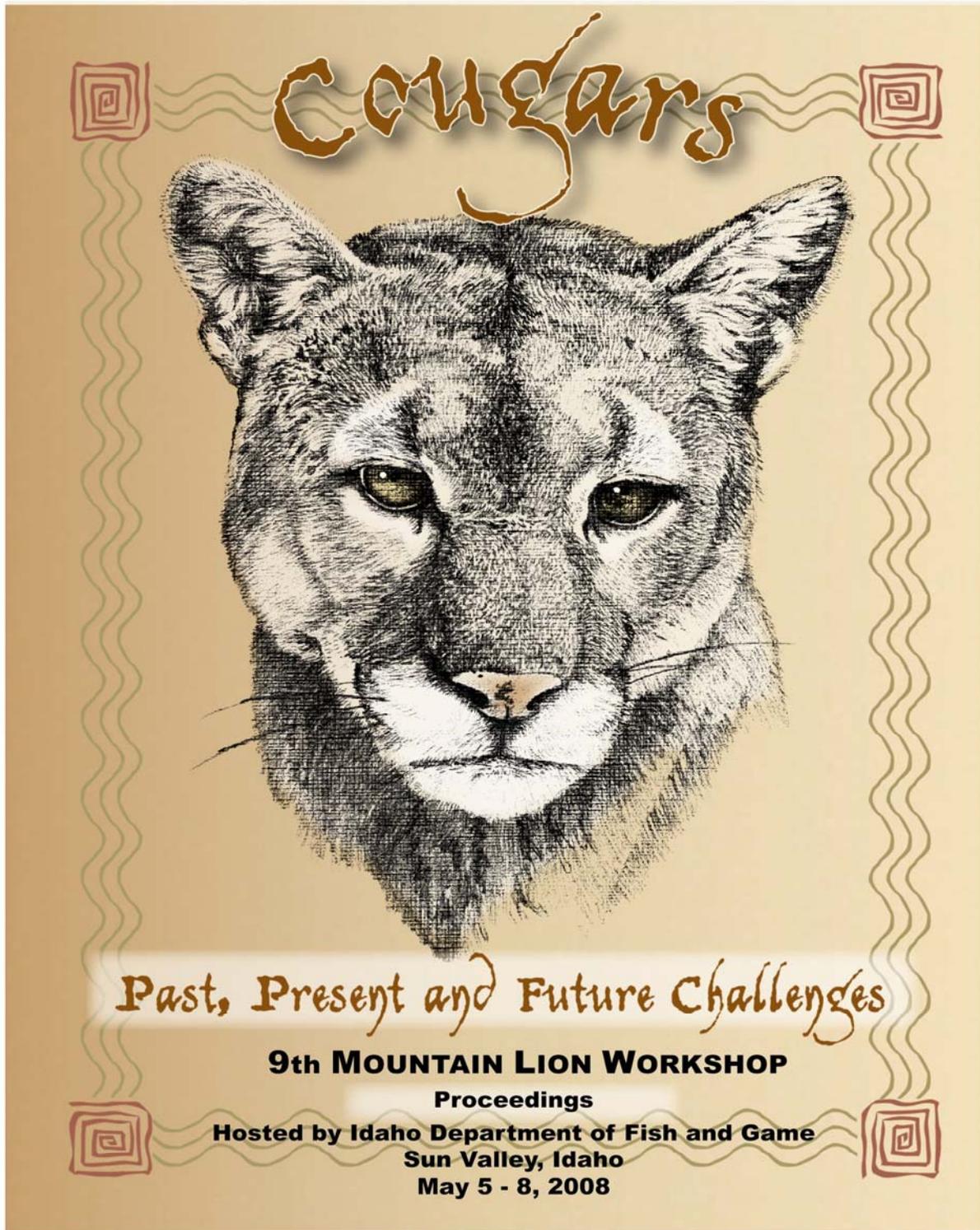
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# Multi-Carnivore and Prey Interactions



## **Cougar Reproduction and Survival Pre- and Post-wolf Reintroduction in Yellowstone National Park.**

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**ABSTRACT** Wolves interact with a variety of carnivore species and their reestablishment may affect population dynamics of other carnivores, as well as alter carnivore community structure. Information regarding how wolf reestablishment influences reproductive and survival rates of sympatric cougars has not been documented, yet is relevant to cougar management and conservation in many western states. We assessed changes in reproductive parameters, survival rates, and factors affecting survival of cougars prior to (1987–1994) and after (1998–2005) wolf reintroduction in Yellowstone National Park. We radio-marked 80 cougars including 55 kittens in 24 litters in the pre-wolf (PW) study and 83 cougars including 52 kittens in 24 litters during wolf presence (WP). Size of nursing litters (<9 weeks old; mean  $\pm$  SD) was similar between PW ( $2.8 \pm 0.7$ ,  $n = 16$  litters) and WP ( $2.9 \pm 0.8$ ,  $n = 14$  litters) studies. Sex ratio of 15 nursing litters (<8 weeks of age) was female-biased (21 females:15 males) during the PW study and was male-biased (15 females:21 males) in 13 nursing litters in the WP study, but were not significantly different (Chi-square test,  $P = 0.157$ ). Kittens reached independence and dispersed from their mothers at approximately 5-months older (Mann-Whitney test,  $P = 0.000$ ) during the WP phase: age at independence averaged  $12.8 \pm 3.2$  months ( $n = 27$ ) during the PW study and  $17.1 \pm 3.2$  months ( $n = 29$ ) after wolf reintroduction. Age at dispersal also differed between the two phases (Mann-Whitney test,  $P = 0.000$ ) and averaged  $13.2 \pm 2.6$  months ( $n = 22$ ) during the pre-wolf study and  $18.2 \pm 3.4$  months ( $n = 25$ ) after wolf reintroduction. Female cougars whose offspring survived to dispersal age had a longer mean interval between litters (Wilcoxon test,  $P = 0.013$ ) during wolf presence ( $21.7 \pm 7.5$  months,  $n = 6$  intervals for 4 females) than before wolf presence ( $12.7 \pm 2.1$  months,  $n = 8$  intervals for 6 females).

We used program MARK to estimate survival rates and multi-model inference to assess a number of predictive models of survival relative to explanatory covariates for cougar demography (birth pulse, age class, dependent young), cougar and wolf density, ungulate biomass, winter severity, rainfall, total homes, road density, escape cover, wolf use, and land management area. Although there were some differences in survival rates for adults,

subadults, and kittens, the study phase and wolf use and density were not important predictors of survival in our models. Model results indicate that survival of adult and independent, pre-dispersal cougars was influenced by (1) sex – females had higher survival rates than males; (2) age – females between 1 and 10 years of age had survival  $>0.80$ , males 3–8 yrs. old had survival of 0.7–0.8; (3) road density during the cougar hunting season – survival declined with an increasing density of km of road/km<sup>2</sup> during the cougar hunting season (Dec–Feb); and (4) elevation – cougars had highest survival at higher elevations. For kittens, results indicate that survival was influenced by (1) age – survival increased rapidly and asymptotes around 0.90 between 0.6 to 0.7 years of age; (2) season – survival was lower during winter; (3) elk calf biomass – survival increased with increasing minimum estimates of calf biomass; and (4) adult male density – kitten survival increased with adult male density (an index of male stability in our studies). Many of the differences in reproduction and survival between the two study phases are consistent with density-dependent influences. Although wolf use and wolf density were not important predictors of survival, cougars responded to wolf presence through spatial shifts which may influence intraspecific strife, reproduction, and possibly survival when examined on a longer time frame than our study.

## **Foraging Ecology of Jaguars in the Southern Pantanal, Brazil: Kill Rates, Predation Patterns, and Species Killed**

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**ABSTRACT** The jaguar (*Panthera onca*) is a large carnivore in the neotropics of Central and South America. To date, kill rates and predation patterns by jaguars remains undocumented. Previous data on jaguar foraging has been mainly determined through anecdotal predation events or scat analysis. We studied the foraging ecology of jaguars living on a cattle ranch in the southern Pantanal of Brazil, documenting kill rates, characteristics of prey killed (species and age), patterns of predation (circadian and seasonal), and duration at the kill site and between kills in relation to prey size. Between October 2001 and November 2003, we captured and equipped 10 jaguars with global positioning system (GPS) collars. During 30 months (October 2001 to April 2004), we collected 11,787 GPS locations and identified 1,105 clusters of locations as sites of concentrated use (e.g., potential kill sites, bed sites, dens). Of these, we found prey remains at 415 clusters (kill sites) and documented 438 prey items at these sites. We found individual jaguars differed in their selection of prey they killed. There were differences in the proportion of native prey versus cattle killed by individual cats. Between males and females, there was no difference in relation to the proportion of cattle they killed. In contrast, male jaguars killed a higher proportion of peccaries than female jaguars. The mean predation rate on all prey for all jaguars combined was  $5.1 \pm 5.0$  (SD) days between kills. Predation rates varied among individuals with the oldest jaguar having the lowest predation rate ( $7.1 \pm 5.6$  days between kills) and the youngest cat having the highest predation rate ( $3.6 \pm 3.4$  days). The length of time in which they killed again depended upon prey size; jaguars stayed longer at a carcass and killed less frequently when preying on larger prey.

## **Cougar Home Range Shifts and Apparent Decrease in Cougar Abundance in the Southern Greater Yellowstone Ecosystem.**

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**ABSTRACT** The stability of large mammalian populations is considered relatively constant over short periods of time (< 5 yrs) unless strong human influences are active or disease plays a role. Dramatic fluctuations in numbers and distribution are rarely documented except as they relate to human-influenced populations. This also appears to be the case in cougar populations. Beginning in 2001 and continuing through 2005, six adult radiocollared cougars (5 Females, 1 Male) were tracked intensively to document cougar home ranges, movements, and predation within the Buffalo Fork River drainage northeast of Jackson, Wyoming. Cougar locations were obtained through ground-based telemetry, GPS collars, aerial telemetry, and capture locations. We used LOAS 4.0 triangulation software to derive the ground-based telemetry locations; all other methods produced a single UTM location. We documented the death and non-replacement of three adult female resident cougars in the focal area. These deaths presented no evidence of human cause or influence. In addition, two adult female residents shifted their home ranges, one of which partially overlapped her previous area and the other seemingly abandoned her previous area. Both of these females were raising kittens of less than one year old at the time of their home-range shifts. The cause of these population changes are difficult to identify. No disease was documented; however, these changes were correlated with concurrent increases in wolves, decreases in prey abundance, and shifts in prey distribution.

## **Wolf and Bear Detection of Cougar-Killed Ungulates on the Northern Range of Yellowstone National Park**

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**ABSTRACT** The use of common habitat and prey resources can lead to both exploitative and interference competition between cougars and other large carnivores. Cougars generally require extended periods, typically 3 to 6 days, to consume a kill. Although caching and concealing the kill in thick cover minimizes detection, other carnivores do detect and encounter cougars at cougar-killed prey. If other carnivores displace cougars, loss of biomass may potentially affect cougar predation rates, survival, and success of rearing offspring. Alternatively, detection of kills potentially benefits other carnivore species. But what factors influence detection of cougar kills by wolves and bears, the cougar's main competitors in northern latitudes?

As part of an 8-year study of cougar-wolf interactions on the Northern Range of Yellowstone National Park, we examined factors that may influence whether wolves and bears detected a cougar kill. Between 1998 and 2005 we cataloged 427 positive or probable cougar-killed ungulates. Wolves visited 87 (20%) of these kills and displaced the cougar from 27 (6%). We limited bear detection data to 234 kills made during spring/summer and fall when bears were active. Bears visited 110 (47%) of these kills and displaced the cougar from 43 (18%) of them. Because there were instances when we could not determine whether visitation was simply scavenging or if displacement occurred, we collapsed visitation and displacements into detections and analyzed wolf detections separate from bear detections. We used logistic regression and multi-model inference to assess a number of models including explanatory covariates of habitat, prey type and size, topography, and season. The odds of wolf detection clearly increased with increasing wolf use and decreasing slope. We suspect slope had a modifying effect on the wolf use variable, which was created from a 95% utilization distribution of wolf locations and therefore does not account for terrain differences. Elevation, topographic roughness, season, prey size, and distance to roads all had 95% confidence intervals around beta estimates that bounded zero. Therefore given the variation in this dataset we cannot be sure of these parameters' true influence. The odds of bear detection were higher for large prey than small prey and in the spring than in the fall, and decreased sharply with the availability of more winter-kill carcasses. Slope, cover type at kill site, and distance to roads all had 95% confidence intervals around beta estimates that bounded zero. An index of bear use was not available for this analysis. Even in high carnivore use areas, terrain features may hinder wolf or bear access and allow cougar kills to remain undetected. These analyses illuminate factors that influence detection of cougar kills, which may indirectly influence cougar survival through loss of prey.

biomass, or directly when cougars are killed during encounters, and promote understanding of habitats that may enhance coexistence of cougars and other large carnivores.

## Cougar Scavenging Behavior and Susceptibility to Snaring at Bait Stations

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**ABSTRACT** In western Canada, snares placed around carrion bait are commonly used to harvest wolves (*Canis lupus*). Snaring can be an indiscriminant harvest method that can include by-catch of several species, including cougar. Cougar are known to scavenge, but the degree to which it makes cougar susceptible to by-catch at bait stations has not been assessed. We present detailed information on cougar scavenging behavior and susceptibility to snaring at a study site in west-central Alberta. We monitored 32 cougar over 3 field seasons (2005-2008) using a combination of GPS and VHF radiocollars. During this period we visited 2,687 clusters of GPS locations for GPS radiocollared cougar and we snowtracked collared and uncollared cougar to locate predation or scavenging events. Scavenging events were recorded only if there was evidence at the site indicating that the monitored cougar did not kill the animal it consumed. We documented at least 53 scavenging events by 23 different cougar. Cougar of all age-sex classes participated in scavenging (47% of cougar scavenged at least once during monitoring). Twenty-nine cougar were monitored intensively with GPS radiotelemetry for continuous periods (29 – 649 days) which allowed us to estimate a scavenging rate for individual animals. Frequency of scavenging was highest for sub-adults (1.38 scavenging events/month) followed by females (0.83/month), and adult males (0.16/month). Scavenging rates for all cougar in winter (1.29 scavenging events/month) were more than 4 times higher than in summer (0.30 scavenging events/month). Seasonal variation in scavenging might be partially explained by carcasses being more readily available during winter at trapping bait stations and hunter-killed ungulate dump sites. Six monitored cougar visited and scavenged from bait stations. Two cougar (1 adult male and 1 adult female) were snared and killed, accounting for 25% of the human-caused mortality of radiocollared cougar during this study. Accidental snaring of cougar must be reported in Alberta and provincial records show that from January 2000 through March 2006, 11% of reported human-caused cougar mortality in our study area was the result of snaring. Our results indicate cougar, especially sub-adults, have a propensity to scavenge and that this behavior makes cougar susceptible to snares. Management plans for cougar in areas where snaring of wolves occurs should account for cougar mortality in snares.

## **Mountain Lion Movement Patterns in Grand Canyon National Park**

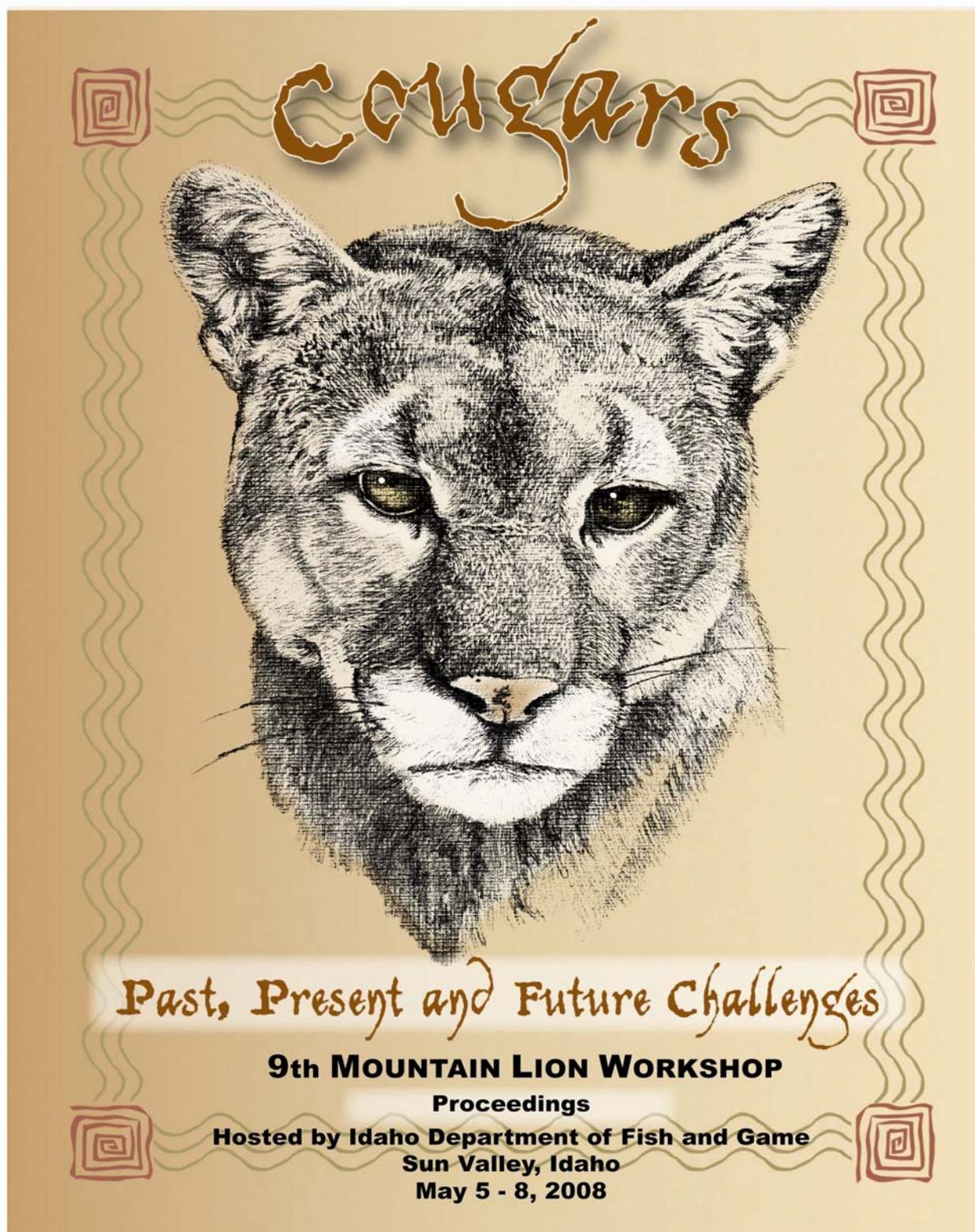
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**ABSTRACT** Grand Canyon National Park received over 4.5 million visitors in 2007. From March to November between 110,000 and 160,000 cars per month enter the Park. Backpacker use in the backcountry amounts to between 280,000 and 300,000 nights per year. Each of these statistics presents Grand Canyon with significant challenges for mountain lion management. In order to begin to understand how mountain lions and humans relate in the canyon we analyzed movement data from 8 lions that were fitted with GPS collars between November 2003 and December 2006. Individual mountain lions were tracked from 8 to 408 days. Four collared lions died during the study with all mortality attributed to humans. Of the 8 mountain lions tracked during this study 7 crossed the major paved roads of the Park. While mean number of crossings per hour for all mountain lions combined was significantly higher for crepuscular and night periods (12.2) than for daylight hours (2.6), at least 1 mountain lion crossed major roads during all hours of the day. Home ranges varied from 437 km<sup>2</sup> to 480 km<sup>2</sup> for males and 198 to 445 km<sup>2</sup> for females. Of 63 kill sites investigated, elk < 1 year old were the most common prey item with numerous caches located near the developed area. Although most of the radio collared cats had some GPS locations less than 1 km from the developed area of the South Rim, no mountain lions were located directly within the developed area. Data from the study have been provided to decision makers involved in on-going transportation and backcountry planning efforts in the Park.



# Genetics and Disease



## Using DNA to Estimate Cougar Populations: a Collaborative Approach

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**ABSTRACT** To better understand population dynamics of cougar, agency managers need long-term data sets collected using standardized methodologies. Short-term studies, while useful for management, are only “snapshots in time”, and provide little information about year-to-year variability or long-term status. Nonetheless, wildlife agencies are typically only able to conduct population estimation projects for 5 years or less because of expenses associated with current research methodologies. The objectives of this project were to: (1) acquire a scientific population estimate of cougars in northeast Washington; (2) test the efficacy and practicality of using DNA capture techniques to estimate cougar population size; (3) manage project costs to allow agencies interested in the technique to potentially conduct the research for decades. We used a capture-recovery methodology but instead of using conventional markers (i.e., radio collars, eartags and tattoos), we used DNA from tissue samples collected from treed cougar as our “capture” and DNA samples collected from harvested cougar as our “recovery”. We tested 5 biopsy dart types from 3 different manufacturers to collect the samples from treed cougars. For the “capture” sample, volunteer hound handlers were deployed throughout the project area between 01 November and 31 December (2003-current) to tree cougars using hounds and obtain a DNA sample via a biopsy dart and CO<sub>2</sub> powered rifle. There was no physical handling required and once a sample was retrieved, the cougar was immediately left in the tree. Each hound handler was assigned to a specific portion of the project area and each was required to work 20-25 days within the allotted timeframe. The “recovery” phase immediately followed the “mark” period (01 January to 31 March) each year. During the hunting season agency personnel collected a tissue sample from all cougar mortalities statewide via a mandatory reporting system. DNA from both samples was analyzed using micro-satellite analysis. The DNA fingerprint analysis consisted of positively identifying 28-36 alleles (14-18 loci) for each tissue sample. Samples that did not produce a minimum of 14 loci were censored. We extracted the specified number of loci from 128 of 163 cougar samples resulting in identification of 100 individual cougars in the “capture” sessions. In the “recovery” sessions, over 62 tissue samples were collected and analyzed from within the project area. Sixteen of the 62 recoveries were previously “captured”. We used Program MARK to estimate population size, which resulted in an average within-year population estimate of 43 cougars (CI 34-58) or 0.87 (CI = 0.65-1.1) cougars per 100km<sup>2</sup>. Over the 4 years, it appears that the cougar population has declined. The cost of the DNA project in year 1 was \$24,110. However because that included microsatellite plates (a one-time expense)

and CO<sub>2</sub> rifles and biopsy darts (both re-usable), the cost for the following 3 years was \$10,885 per year. We believe the technique was successful at generating reliable, repeatable population size estimates at an affordable cost. As such, we believe it may be a useful technique for other cougar managers to utilize.

## Estimating Lion Population Abundance Using DNA Samples in the Blackfoot Drainage of West-Central Montana

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**ABSTRACT** Mountain lion (*Puma concolor*) DNA was collected from late November 2005 through February 2006 from a 1,377-km<sup>2</sup> area in the Blackfoot Drainage of west-central Montana to evaluate the use of DNA sampling to estimate lion abundance. Three houndsmen spent 80 days systematically hunting, treeing lions and collecting tissue samples using biopsy darts fired from a CO<sub>2</sub>-powered rifle. They drove 920 km, snowmobiled 5800 km and hiked 65 km. Thirty four tissue samples were collected representing 20 individual lions (estimated to weigh over 34 kg). All tissue samples were successfully genotyped using 12 variable, microsatellite loci, which allowed ample power to discern individuals. In addition, 60 lion tracks were backtracked, 158 hair samples were collected and 133 analyzed. Twenty percent of backtracks and 13% of the hair samples resulted in quality DNA for individual and sex identification. During the first sampling period (late November–January), 20 individual lions were genotyped from 17 tissue and 3 hair samples. During the second sampling period during February, 12 individual lions were genotyped from 10 tissue and 2 hair samples. Eight of the 12 lions during the second sampling period were recaptures. Overall, a total of 24 individual lions were identified (14 females, 9 males, and 1 unknown). A simple Lincoln-Petersen index produces an abundance estimate of 29 lions with a 95% CI that ranged between 25 and 33, resulting in an estimated density of between 1.8 and 2.4 lions per 100 km<sup>2</sup>. These preliminary results suggest that DNA sampling may be a valuable monitoring technique to estimate lion abundance.

## Estimation of the Bottleneck Size in Florida Panthers

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**ABSTRACT** An estimate of genetic variation in museum samples (1890s) and contemporary (1980s) samples for Florida panthers (*Puma concolor*) was obtained at both nuclear and mitochondrial DNA loci. Although the sample size and number of loci was limited, for microsatellite diversity, contemporary samples had 32.5% of the heterozygosity of that found in museum samples. The mitochondrial DNA diversity was 0.60 in museum samples and 0.00 in contemporary samples. Using a population genetics approach, we have estimated that to reduce diversity at microsatellite and mitochondrial DNA loci to this extent, an effective bottleneck size of approximately two individuals for several generations is required. Given the ratio of effective population size to census population size ( $N_e/N$ ) of 0.315, estimated from Yellowstone pumas, this translates into a census size of 6.2. Overall, the census population was 41 in non-bottleneck generations and 6.2 for the two bottleneck generations. This low population size is likely to be responsible for the reduction in fitness, or inbreeding depression, observed in Florida panthers prior to the genetic restoration that introduced Texas individuals into Florida.

## Evaluation of Noninvasive Genetic Sampling Methods for Cougars Using a Radio-Collared Population in Yellowstone National Park.

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**ABSTRACT** Reliable information on populations is essential for the successful conservation and management of many carnivore species. Carnivores such as cougars (*Puma concolor*) are particularly difficult to study due to their large home-range sizes, low densities and secretive nature. The conventional method for monitoring cougar populations involves capture, tagging and radio-collaring, but this method is time-consuming, expensive and logistically difficult. For difficult-to-study species such as cougars, noninvasive genetic monitoring may be a useful alternative. DNA extracted from hair or scat can be used to identify individuals, determine genders and relationships, examine patterns of gene flow and estimate population size. The ability to identify individuals from samples collected through noninvasive sampling methods provides many opportunities for developing population-monitoring tools, but the utility of these survey methods is dependent upon the collection of samples and the accurate genotyping of those samples. In January 2003, we initiated a 3-year study to evaluate the merits of noninvasive genetic sampling methods for monitoring cougar populations in Yellowstone National Park (YNP), USA. The goals of this study were to develop a noninvasive hair sampling method for cougars and to examine the reliability of the genetic data derived from those hair samples. This study was conducted in conjunction with the Yellowstone Cougar Project, a long-term research project on cougars in YNP. We used 2 noninvasive sampling methods concurrently, hair snares and snow tracking, to obtain hair samples from free-ranging cougars in the Northern Range of YNP. We compared the effectiveness of the 2 collection methods to obtain hair samples and produce accurate individual identifications and genders. We also evaluated the accuracy of the noninvasive genotypes by comparing them to genotypes from blood and tissue samples collected during cougar capture. The results from this study show that snow tracking is a better method than hair snaring for collecting hair samples in YNP. The genetic data generated from these samples produced accurate individual identifications and genders.

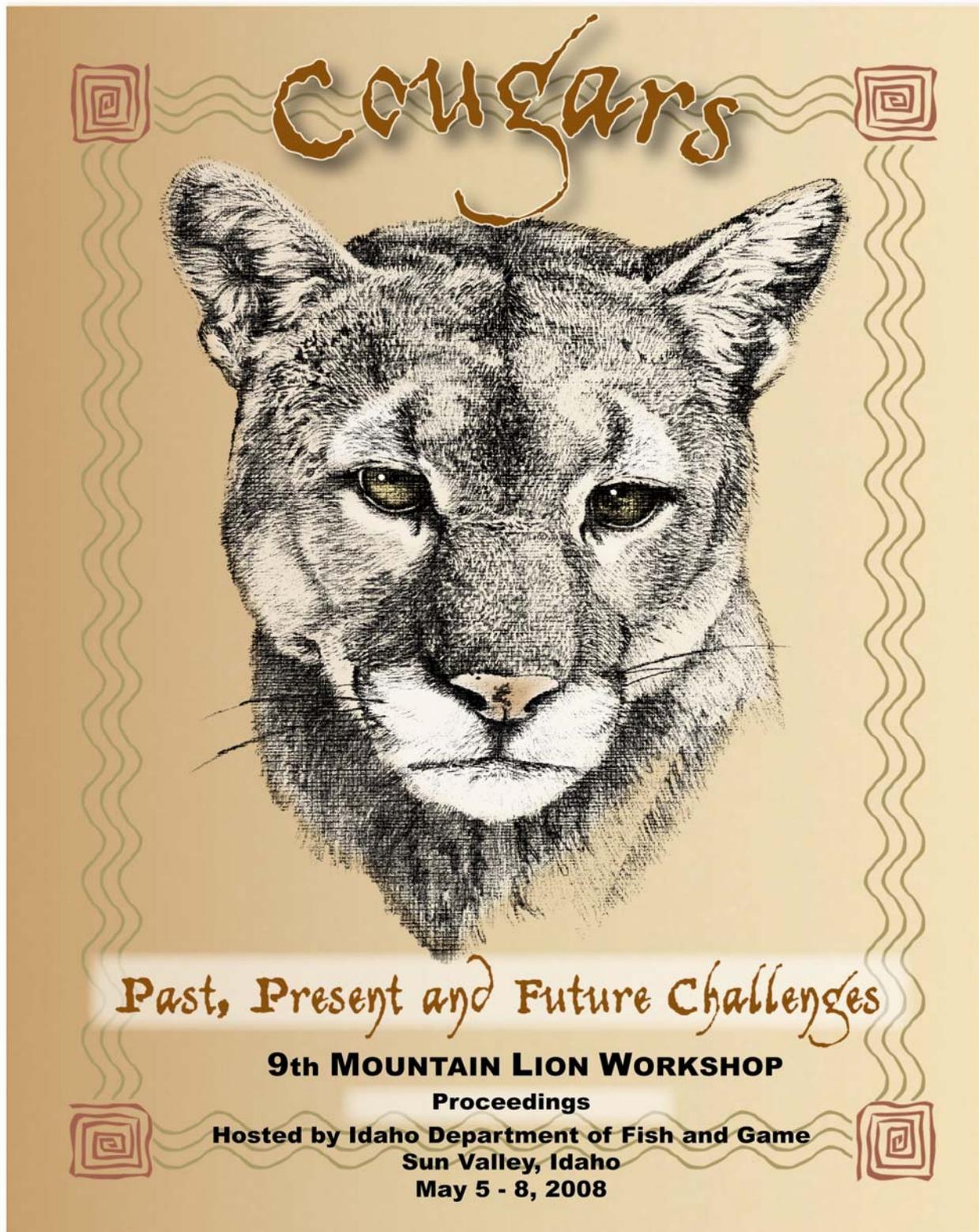
## A Preliminary Retrospective on the Implementation of Genetic Introgression in the Florida Panther

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**ABSTRACT** The decline of populations of large carnivores is typically an unfortunate result of varied anthropogenic factors that ultimately expedite endangerment and extinction. The Florida panther (*Puma concolor coryi*) is a perfect example of the plight faced by many populations of large carnivores in the 20th century. Extirpation of panthers throughout most of their range resulted in a small (< 50) remnant population isolated in southern Florida by the 1980's. Early research revealed that portions of the population appeared to be impacted by several correlates of inbreeding. Amending detrimental influences of inbreeding depression often associated with endangered populations should theoretically be possible via the introduction of novel genetic variation from conspecifics. Herein, we report the historical decline of the Florida panther, the subsequent initiation of a genetic introgression program in 1995 via the release of Texas cougars (*Puma concolor stanleyana*), and findings derived in the ensuing decade of research. We incorporated field observations, biomedical records, and genotypic data from 21 microsatellite loci for panthers sampled between 1970 and 2007 to assess changes in genetic variation, population structuring, and kinship in pre- and post-introgression periods. We also delineated temporal trends regarding observations of congenital defects and reproductive abnormalities in the panther population.

Heterozygosity, average number of alleles, and measures of genetic structuring and distance have all increased in cohorts of panthers born since the initiation of the introgression project. Conversely, cases of atrial septal defects and cryptorchidism have decreased in generations since the introduction of Texas cougars. A slow and steady expansion of the Florida panther population (90-100 animals) has ensued in the decade following genetic introgression. While inbreeding and genetic variation remain issues of concern, recovery of panthers continues to hinge largely on the preservation of usable-space and improving prospects for recolonization of former range in other regions in Florida and the southeastern U.S.

# Population Estimation and Dynamics



## Evaluation of Cougar Population Estimators in Utah

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**ABSTRACT** Numerous techniques have been proposed to estimate or index cougar (*Puma concolor*) populations, but few have been applied simultaneously to populations with reliable estimates of population size. Between 1996 and 2003, we evaluated the relative efficacy and accuracy of multiple estimation and index techniques for populations at 2 locations in Utah, Monroe Mountain and the Oquirrh Mountains. We used radio-tagging followed by intensive monitoring and repeated capture efforts to approach a complete enumeration of the populations. We used these benchmarks to evaluate other population estimates (Lincoln-Petersen mark-recapture, helicopter-survey probability sampling, catch-per-unit-effort) and indices (scent-station visits, track counts, hunter harvest). Monitoring over 600 scent-station-nights using different attractants, June–September in 1996 and 1997, yielded a single cougar visit. Summer track-based indices reflected a 54–69% reduction in population size on the Monroe site and a numerically stable population on the Oquirrhs, but relationships between indices and the benchmark population estimates varied among techniques. Population estimates derived from helicopter-survey probability sampling exceeded reference population estimates by 120–284%, and bootstrapped estimates of standard error encompassed 25–55% of the population estimates (e.g.,  $5.6 \pm 1.4$  cougars/100 km<sup>2</sup>). Despite poor performance in predicting cougar population sizes, track-based estimates may provide better indices for monitoring large changes in population trends (i.e., with low precision). However, we recommend using multiple indices after determination of a more rigorous initial population estimate for managing populations of conservation concern and when considering connectivity to determine potential refuge sites for regional management (e.g., management by zones).

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## Dynamics and Demography of a Central Washington Cougar Population

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**ABSTRACT** From 2002 – 2007, we monitored a cougar population in central Washington to investigate demographic effects and dynamics of a relatively light harvest regime (removals = 0.09 – 0.47%), and to test the hypothesis that cougars are self-regulating. We recorded fecundity through den site investigation and snow tracking, and mortality by weekly telemetry. We estimated survival rates for collared kittens (0-1 yr), juveniles (1-2 yr), and adult (2+ yr) males and females, and input the parameters in a dual-sex Leslie Matrix population model to predict deterministic and stochastic growth. We then compared modeled growth to the observed growth rate, which we estimated by constructing life histories of all known cougars (collared, harvested, and other uncollared mortalities) in the study area. Annual densities were calculated based on the 95% kernel composite female home range. Preliminary results show that despite a high female survival rate (0.908) and a high stochastic growth rate (1.10), densities of cougars did not increase (mean average density = 1.72 adults/100km<sup>2</sup>) in our study area. We believe that cougars are compensating for high growth through emigration. Results will be updated.

## Variation in Cougar (*Puma concolor*) Survival by Individual Traits, Density, and Seasonal Weather.

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**ABSTRACT** The vital rates (fecundity, survivorship) and migration rates of an animal population determine its size and composition, and represent the combined life-history performances of its constituents. Understanding how individual traits, population characteristics, and extrinsic factors influence fecundity and survivorship is fundamental to explaining the dynamics of a population. It can also reveal valuable insights about the species' life-history strategies. In addition, being able to predict changes in vital rates, based on known associations with key explanatory variables, is important when managing for a stable population.

To examine how survival varied with a cougar's identity (e.g., age, sex) and behavior (e.g., habitat use), conspecific density, and seasonal weather, we analyzed long-term data from a hunted population of cougars in South West Alberta studied by Jalkotzy and Ross during 1981-1994. We developed generalized-linear models to identify different influences on cougar survival. Habitat use was measured in a novel way, which accounted for extreme behavior, and out-performed measuring the average habitat used.

Cougars died mostly during winter. Recently-independent offspring, older individuals (>8 yrs), and males, experienced greater mortality. During winter, survival increased significantly if cougars frequented habitats >1.4 km (♀) or >2.2 km (♂) from a highway, between 1445-1678 m (♀) or 1513-1646 m (♂) elevation, and with <3% (♀) or <41% (♂) closed-canopy cover (>50% and >45% open-canopy cover, respectively) within 1 km<sup>2</sup> of a cougar's location. Winter survival was higher during dry winters and following wet springs. Density-dependent effects on winter survival were not evident.

We suggest that future challenges will be linking vital rates to habitat use, studying the effects of weather on survival, and applying extensive analytical techniques to long-term demographic data of cougars.

## **The Idaho Backcountry: Is it Still a Source Population for Cougars in Idaho?**

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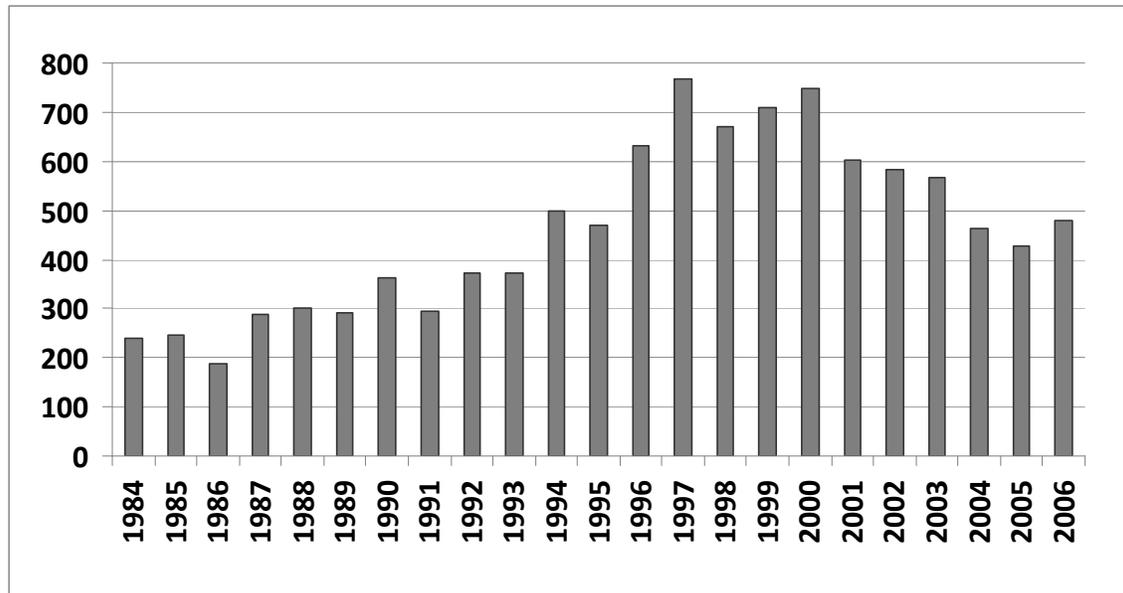
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Maurice Hornocker conducted the first major research on cougar (*Puma concolor*) ecology and determined that cougars living in the remote central Idaho wilderness functioned as a source population (Hornocker 1970). Hornocker (1970) concluded that the wilderness population was stable, despite high productivity of the study population, because subadult cougars dispersed long distances from the wilderness rather than remain in their natal population. Pulliam (1988) defined a source population as one with high productivity and reproductive surpluses that contributed immigrants to sink habitats. Sinks were populations where mortality exceeded reproduction and the population could not be maintained without immigration. Large source populations stabilize metapopulations, while large sinks can contribute to population decline over a large area (Logan and Sweaner 2001).

Prior to Hornocker's research and the classification of the cougar as a big game animal in Idaho in 1972, most cougars occupied the less-accessible central Idaho wilderness. Wilderness access for cougar hunting was limited to flying to backcountry airstrips, staying in camps and traveling and hunting with hounds by horseback and on foot. More accessible areas, those outside of wilderness, had roads that could be driven with a truck or snowmobile in winter to look for tracks, where hounds could be released. Cougar numbers increased in Idaho over the next 25 years as cougars recolonized much of the state. Changes in distribution and numbers of cougars occurred in more accessible areas where they had been heavily harvested prior to 1972 (Power 1985). Idaho Department of Fish and Game Mountain Lion Management Plans have incorporated the role of wilderness source populations in contributing dispersing cougars to areas with higher harvest levels (Power 1985, Harris 1991, Rachael and Nadeau 2002), therefore allowing high harvest levels to be maintained locally through immigration (Nadeau 2007). Annual cougar harvest in Idaho increased from 1973 until 1997 and has declined and stabilized since that time (Fig. 1). Wildlife agencies in other western states and provinces have reported similar cougar harvest trends, despite varying hunting regulations, including British Columbia (Austin 2005), Montana (DeSimone et al. 2005), Utah (McLaughlin 2003), and Wyoming (Wyoming Game and Fish Department 2006). Statewide harvest trends and cougar depredation trends are likely correlated with changes in cougar populations. In contrast, smaller-scale Data Analysis Unit (DAU) harvest trends may be more influenced by local source and sink dynamics, differences in hunting regulations

and access, and annual variations in hunting weather conditions and harvest rates. If cougar harvest rates in Idaho have increased while the population has declined, source populations may no longer be able to maintain adequate reproductive output to supply adjacent sink areas with dispersers. Cougar harvest rates are difficult to calculate in most Game Management Units (Units), because cougar population size is unknown. Unit 26 – Big Creek, a wilderness unit, is an exception. Cougar population size was determined during 4 research projects in Unit 26 from 1965-2003 (Hornocker 1970, Seidensticker et al. 1973, Quigley et al. 1989, Akenson et al. 2005).



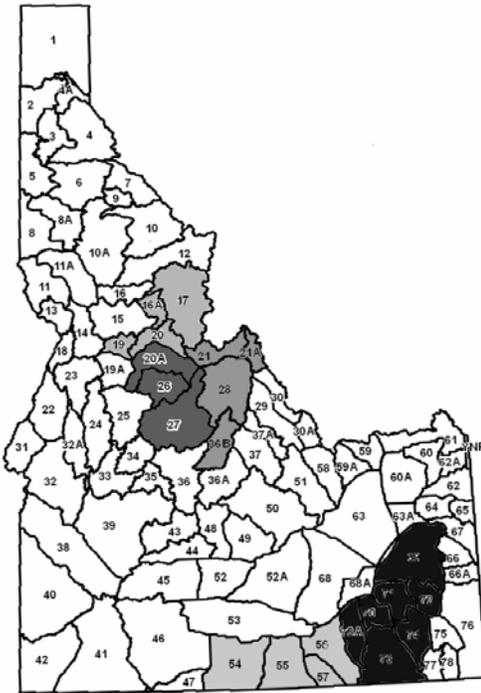
**Figure 1.** Idaho cougar harvest 1984-2006 (from Idaho Department of Fish and Game Big Game Management Records database).

A cougar source population is characterized by older aged residents with infrequent vacancies of home range areas, a high reproductive rate and high dispersal rate. A sink population is characterized by frequent replacement of resident cougars, resulting in lower male and female ages and a lower reproductive rate: mortality exceeds production: and immigration exceeds dispersal. Differences in cougar population age and sex ratios and harvest age and sex composition over time should be detectable between source and sink populations.

Our objectives were: 1) compare harvest-age and sex-composition data among 5 areas to determine whether the wilderness cougar population still functioned as a source population and 2) to evaluate changes in wilderness cougar population size and harvest level over a 40-year period. We predicted that the wilderness cougar harvest rate had increased to a degree that brings into question whether this population remains as a source.

## Study Areas and Methods

We selected 5 of 18 Idaho Cougar Management DAUs (Fig. 2) for comparisons of harvest-age and sex-composition. The five areas were selected based on differences in cougar population trend, hunter access, harvest trends, availability of research data, and habitat separation (for some units). These areas included: 1) Warren DAU (Units 19A, 20A, 25A, 26, 27,) within and adjacent to the Frank Church Wilderness, 2) Selway DAU (Units 16A, 17, 19, 20) within the Selway, Frank Church, and Gospel Hump Wildernesses and adjacent roadless areas, 3) Salmon DAU (Units 21, 21A, 28, 36B) adjacent to the Frank Church Wilderness, and 4) Pocatello DAU (Units 69, 70, 71, 72, 73, 73A, 74) and 5) Oakley DAU (Units 54, 55, 56, 57). The Pocatello and Oakley DAUs were in southeast Idaho, separated from the other DAUs by unsuitable cougar habitat. During the 1980s and 1990s, the Selway DAU and wilderness units of Warren DAU contained productive, stable cougar populations that were not heavily harvested (Power 1985, Harris 1991). The Salmon DAU and roaded units of Warren DAU also supported high cougar populations, but had greater hunter access. The cougar population trend was increasing in the Salmon DAU and roaded units of the Warren DAU, although exploitation rates were variable and some populations were partly sustained by immigration from wilderness cougar populations (Power 1985, Harris 1991). The Pocatello DAU and Oakley DAU had low numbers of cougars, some marginal habitat, low harvest rates, and the population trend was increasing (Power 1985, Harris 1991). Since 1998, Idaho cougar harvest has declined statewide and in most DAUs (Nadeau 2007).



**Figure 2.** Cougar Data Analysis Units used for Idaho harvest data comparisons: Warren DAU, Selway DAU, Salmon DAU, Oakley DAU, and Pocatello DAU.

Wilderness DAUs were considered valuable because they served as reservoir areas where, due to difficult access and topography, lenient hunting seasons could be allowed without significantly reducing dispersal into adjacent areas like the Salmon DAU and parts of Warren DAU (Power 1985, Harris 1991). To evaluate changes in cougar harvest rate through time, we selected Unit 26 which is contained within the Frank Church River of No Return Wilderness area. In addition to state harvest records, four cougar research projects (Hornocker 1970, Seidensticker et al. 1973, Quigley et al. 1989, Akenson et al. 2005) were conducted in Unit 26 resulting in cougar population estimates between 1969 and 2003.

### **DAU Comparisons**

We compared Idaho Department of Fish and Game cougar harvest data from the 1972-2006 Big Game Management Records database (B. Ackerman, Idaho Department of Fish and Game, unpublished data) from 2 areas (Warren DAU and Selway DAU) designated by Idaho Department of Fish and Game as source populations, an adjacent sink area (Salmon DAU), and 2 distant areas (Pocatello DAU and Oakley DAU) that historically had low harvest levels, but had increased harvest since the 1990s. We compared long-term harvest trends among DAUs from 1983-2006 and compared the mean proportion of females in the harvest per decade (1980s, 1990s, 2000s) among DAUs. We pooled harvest data for each DAU from 1998-2006 because of low sample sizes and high annual variation in age and sex composition. We evaluated differences among DAUs in harvest age–sex composition using 2 age classes: subadults (kitten to 2 years old) and adults (at least 3 years old) and compared adult versus subadult proportions, proportion of females and adult females in the harvest. We evaluated differences among DAUs in age structure of harvested males using 4 age classes: kitten to 2 years old, 3 years old, 4-7 years old, and at least 8 years old. We used a subset of Warren DAU that only included wilderness units (Units 20A, 26, 27) for the comparisons of age–sex data, male ages, and the proportion of female cougars in the harvest.

### **Harvest Rate Change**

Since 1973, Idaho Department of Fish and Game has sustained a mandatory check of harvested cougars and maintains a database that includes annual harvest numbers and sex composition by game management unit. The cougar harvest database has included age data from tooth cementum annuli since 1988. We calculated mean annual cougar harvest in Unit 26 by decade from the 1973-2006 Big Game Management Records database (B. Ackerman, Idaho Department of Fish and Game, unpublished data).

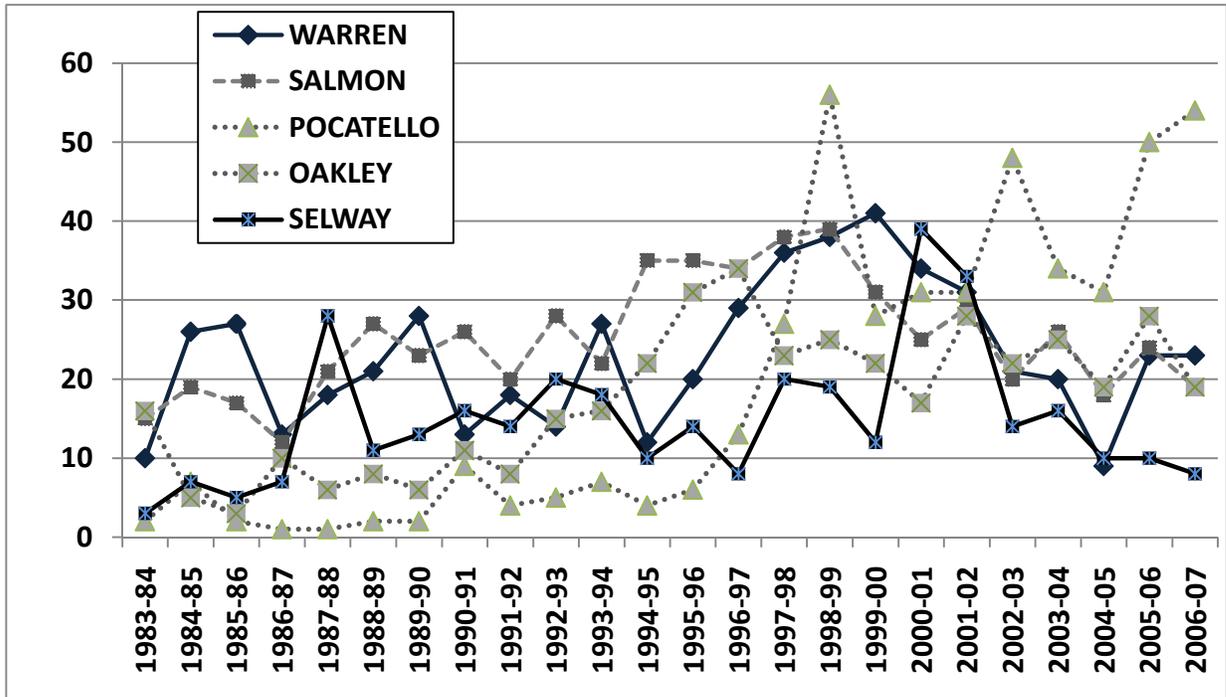
In Unit 26, we compared the change in harvest levels with changes in resident cougar populations by decade over a 40-year period to assess changes in cougar harvest rate. We calculated a harvest ratio for each decade based on mean annual harvest relative to resident cougar population estimates from research. Harvest ratios were used as an index to harvest rates, because numbers of subadult and transient cougars were not known for research population estimates.

We calculated the proportion of resident adult cougars and resident adult females harvested annually in Unit 26 during 1998-2006 from the proportion of adult and adult female age–sex classes harvested during 1998-2006 in the Warren DAU, the mean annual harvest in Unit 26, and the number of resident adults and resident adult females identified during the 1999-2002 research period (Akenson et al. 2005). These calculations assumed that all adult cougars in Unit 26 were residents and the adult population throughout the 1998-2006 time period was within the range of resident cougar population estimates determined during the 1999-2002 research.

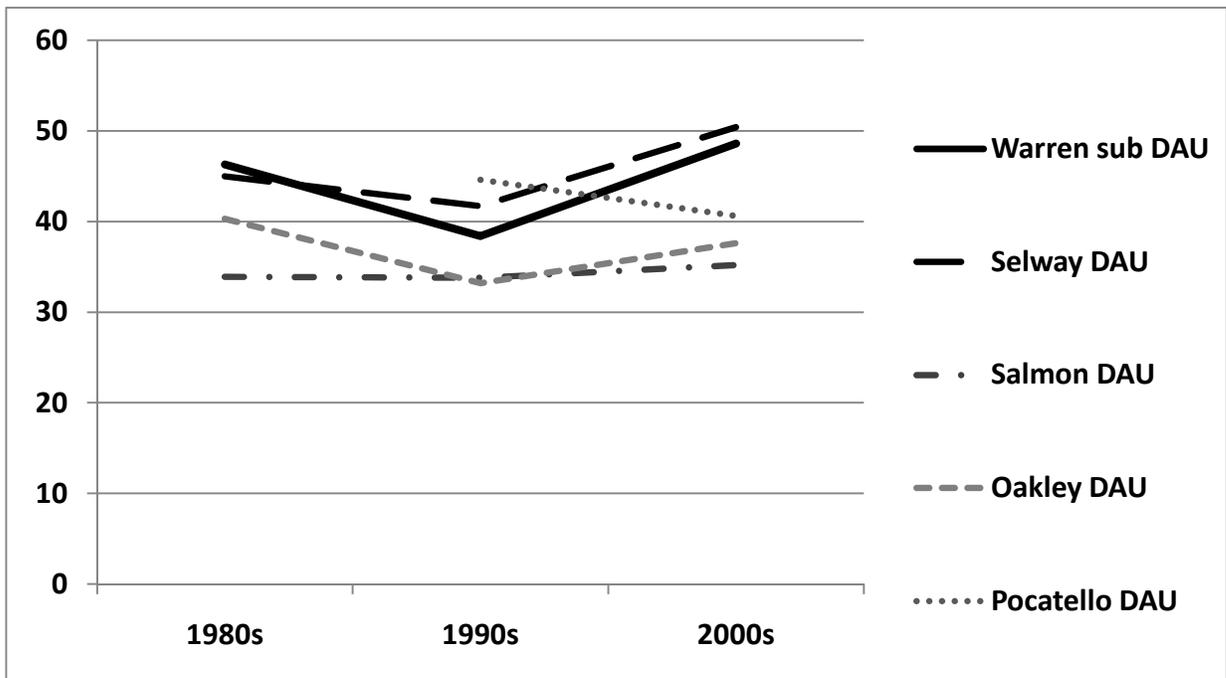
## **Results**

### **DAU Comparisons**

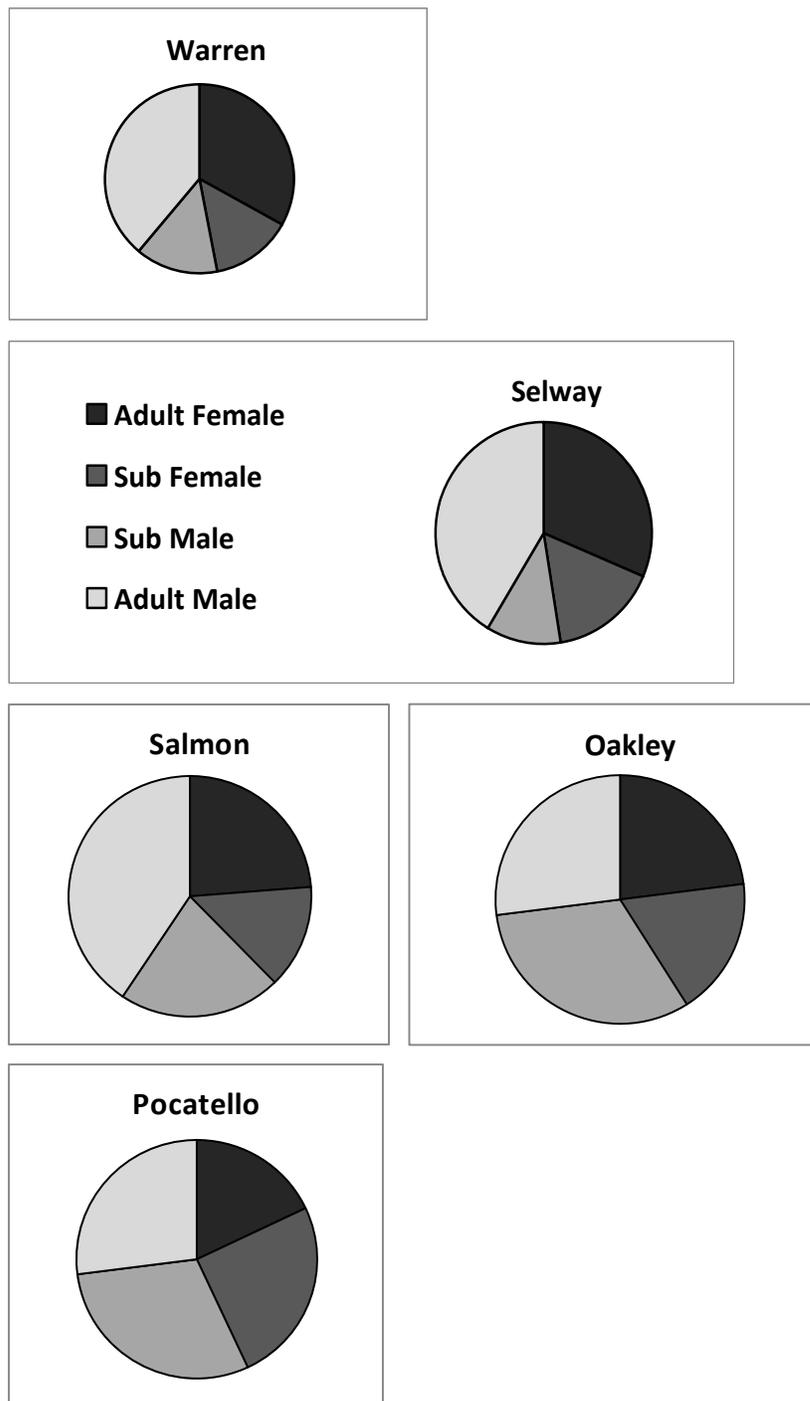
Although there was considerable annual variation among DAUs, 4 of 5 study DAUs had declining cougar harvest levels after a late 1990s peak, with the exception being the Pocatello DAU (Fig. 4). Over a 3-decade period the proportion of females in the harvest first decreased slightly then increased for all study DAUs except Pocatello DAU (Fig. 5). Consistently, the highest proportions of females in the harvest were in the 2 wilderness DAUs: Warren and Selway. Cougar harvest during the period 1998-2006 consisted primarily of adult animals for Warren, Selway and Salmon DAUs and subadults for Pocatello and Oakley DAUs (Fig. 6). Females represented 47% of the Warren and Selway DAU harvests during 1998-2006, among the highest proportions in the state, while Salmon DAU, with 38% female harvest had the lowest proportion of females in the harvest statewide. Adult females represented 33% of harvest in Warren DAU and 31% of harvest in Selway DAU, which were the highest proportions of adult female harvest among all 18 Idaho Cougar DAUs. The Pocatello DAU had only 18% adult females in the harvest; the lowest proportion statewide. Selway, Warren, and Salmon DAUs had a greater proportion of adult males than subadult males in the harvest during 1998-2006, while Pocatello and Oakley DAUs had a greater proportion of subadults (Fig. 6). Older age classes of males were well represented in cougar harvests from Warren, Selway, and Salmon DAUs, but not in Pocatello and Oakley DAUs (Fig. 7).



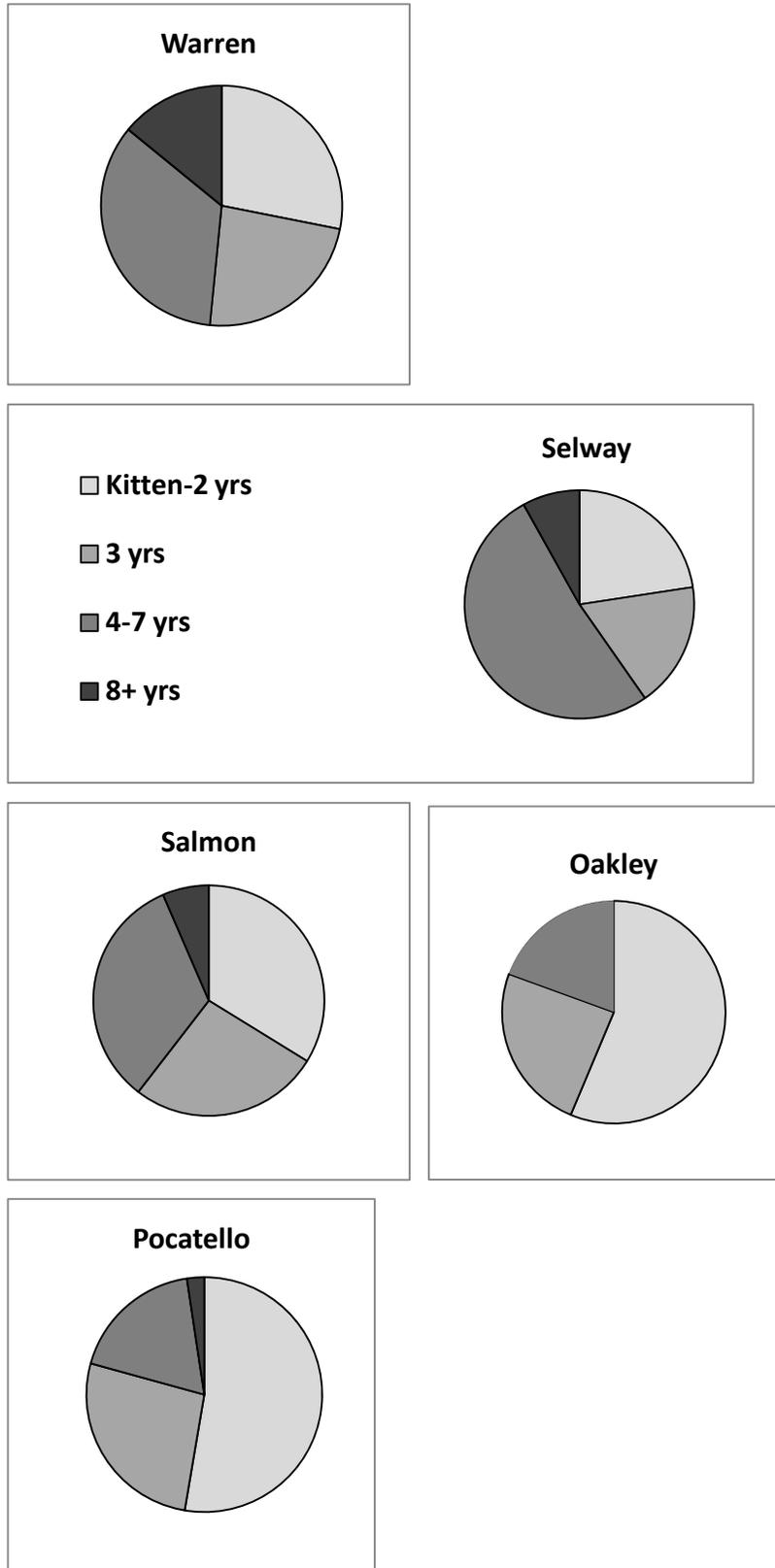
**Figure 4.** Cougar harvest by DAU, 1983-2006 (Idaho Department of Fish and Game Big Game Management Records database).



**Figure 5.** Proportion of female cougars in harvest by Data Analysis Unit during 3 time periods in Idaho.



**Figure 6.** Cougar harvest by sex and age in 5 Idaho Data Analysis Units, 1998-2006.

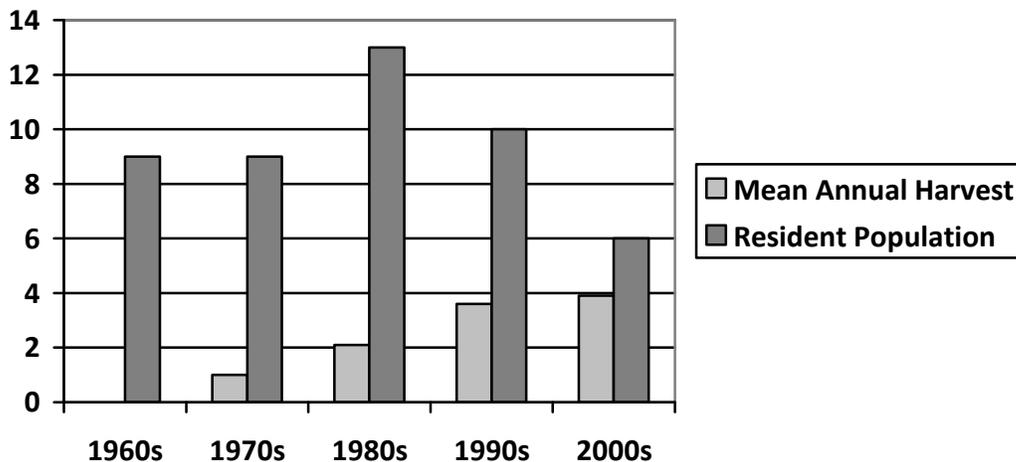


**Figure 7.** Cougar harvest age composition of males in 5 Idaho Data Analysis Units, 1998-2006

## Harvest Rate Change

Four long-term cougar research projects were conducted in Unit 26 using capture-recapture and radio-telemetry techniques to produce a resident cougar population estimate for each time period. Hornocker (1970) and Seidensticker et al. (1973) determined that the cougar population was stable with a stable-to-increasing elk and mule deer prey base and minimal harvest (no harvest in the first period and mean annual harvest of less than 1 cougar in the second period). Each study identified a resident cougar population of 6 females and 3 males during 1965-1969 and 1970-1973 study periods. Quigley et al. (1989) found that the resident cougar population had increased to 10 females and 3 males simultaneously with an increased prey base, primarily elk, and light harvest (mean annual harvest of 1.0 cougars) during the 1984-1986 period. Akenson et al. (2005) documented a declining resident cougar population that initially consisted of 6 females and 4 males, which then decreased to 4 females and 2 males during the 1999-2002 time period. This decline occurred concurrently with high cougar harvest (mean annual harvest of 3.8 cougars), a declining elk prey base, new wolf use in the unit, and a large-scale wildfire in 2000 that significantly altered the environment.

Cougar harvest in Unit 26 increased nearly 4-fold over the past 4 decades. This is in contrast to the trend from resident cougar population estimates from 4 cougar research projects conducted in Unit 26 during 1965-2002 (Fig. 3). The consequence of higher harvest in Unit 26 without a similar change in the cougar population was an increase in the harvest rate on cougars. The harvest ratio (harvest per resident adult population) for each decade increased from 0.11 during 1960s and 1970s research to 0.17 during the 1980s, and 0.34 to 0.67 during the 1999-2002 research period, reflecting an increasing harvest rate trend over time. During the 1998-2006 time period, we estimated 29-48% of resident adult cougars and 21-32% of resident adult female cougars were harvested annually in Unit 26.



**Figure 3.** Unit 26 – Big Creek mean annual cougar harvest by decade (Idaho Department of Fish and Game Big Game Management Records database) compared to resident cougar population estimates from Big Creek research in 1965-1969 (Hornocker 1970), 1970-1973 (Seidensticker et al. 1973), 1984-1986 (Quigley et al. 1989), and 1999-2002 (Akenson et al. 2005).

## Discussion

A population can lose its ability to function as a source population due to a decrease in productivity and recruitment or an increase in mortality, such that substantially fewer subadults are available to disperse to other areas. The original population size could remain stable, even with the lack of dispersers, until additional mortality and lack of recruitment caused the population to decline.

In the central Idaho wilderness, where cougar populations have been managed to supply dispersing animals to surrounding areas, hunter harvest should be managed to be light enough to allow for continued high productivity. The central Idaho wilderness (Warren and Selway DAUs) has been considered an area with difficult access, so cougar hunting seasons have been more liberal than other parts of the state (Rachael and Nadeau 2002). Wilderness cougar hunting opportunities in Idaho were expanded in 2002 in response to big game hunter concerns about potential combined effects of cougars and wolves on elk populations (Rachael and Nadeau 2002). Cougar hunters responded by increased use of wilderness airstrips located in big game and cougar wintering areas and of hunting outfitter facilities and services within the wilderness. These factors contributed to the recent increase in Unit 26 cougar harvest levels and the high adult cougar harvest rate.

Logan and Sweanor (2001) and Anderson and Lindzey (2005) experimentally manipulated cougar populations to determine the effects of removal on populations. Logan and Sweanor (2001) determined that when off-take through capturing and translocating cougars exceeded 28 percent of the adult population, the cougar population declined. Anderson and Lindzey (2005) reduced a cougar population through intensive hunter harvest, a 43% harvest rate, and then allowed the population to recover during a period of light hunter harvest, an 18% harvest rate. Ross and Jalkotzy (1992) determined that a cougar harvest rate of 11% did not prevent the population from growing. In comparison, for Idaho's Unit 26, the 1998-2006 estimated mean annual harvest rate of 29-48% of resident adult cougars strongly suggests that continuing to assume the wilderness populations function as sources should be questioned and harvest rates revisited for certain units. It should not be assumed that wilderness habitats, or any habitats, always function as a source or a sink population.

Resident adult females, the breeding component of a cougar population, are the most important age-sex class for directly influencing population productivity and growth (Lambert et al. 2006). Adult female cougars invest extensive time in maternal care and 40 to 88% of resident females produce new litters each year (Logan 1983, Logan and Sweanor 2001, Ruth et al. 2003). An average of 72% (range = 40 to 100%) of resident females support dependent offspring <18 months of age (Ruth et al. 2003). Sustained adult female mortality results in decreased production, negative population growth, and in turn affects the availability of dispersers as immigrants into sink populations. Although cougar harvest composition does not necessarily represent the age and sex structure of a population, harvest composition can be used with other factors to predict cougar population trends. Anderson and Lindzey (2005) found that after several years of intensive cougar harvest, a population decline resulted, at which point the adult females

had increased to over 25% of the cougar harvest composition. This result was as they predicted given their hypothesis that adult females were the age-sex class least vulnerable to harvest and would be last to increase in the harvest composition following intensive harvest. They suggested that a high proportion (over 25%) of adult females in the harvest may be an indicator of a declining trend in a hunted population. The even greater proportions of adult females in the 1998-2006 cougar harvest in Idaho's Warren DAU (33%) and Selway DAU (31%) strongly suggest that a decline has occurred in these wilderness cougar populations due to intensive harvest. Alternatively, source populations, such as the wilderness DAUs would be expected to have a greater proportion of adult females than sink populations, and therefore would be more likely to have a greater proportion of adult females represented in the harvest composition than sink populations. Even if this explains the high adult female proportion in wilderness DAU harvest composition, sustained high mortality of adult females (such as the 8 years of harvest from the wilderness units, 1998-2006) will alter that population's ability to always function as a source. In addition, any decrease in production from prolonged mortality of adult females may result in increased reliance of wilderness units on immigrants from surrounding areas as fewer philopatric offspring would be available to replace adult losses. Decreased productivity from frequent turnover of home ranges could also contribute to a decline in the population. Unlike the adverse effects on productivity associated with high adult female harvest, the representation of older age class male cougars in the wilderness DAUs' harvest composition suggests that the male component of this population is less intensively harvested.

### **Management Implications**

There are broader population implications derived from the recent high cougar harvest rates in wilderness DAUs, that not only affect cougar populations and harvest within those DAUs, but first affect surrounding areas. If Idaho wilderness DAUs no longer function as source populations, the lack of dispersing subadults would affect adjacent sink area cougar populations and harvest levels where high hunter harvest would no longer be compensated for by immigration. Wilderness cougar populations would be maintained longer than adjacent sinks, because philopatric offspring would obtain available home ranges. These cougar populations would decline only after sustained high mortality and decreased productivity. If wilderness cougar populations now have a reduced capability to function as source populations, this may be one factor contributing to declining harvest trends in Idaho.

After peaking in the late 1990s, declines in cougar harvest and livestock depredations in Idaho and other western states suggest that on a regional scale, cougar populations have also declined. Adaptive management depends on updating state cougar management plans addressing and incorporating recent changes in cougar population trend such as recent indications that across the west, cougar numbers are stable or declining. Annual DAU harvest statistics from Idaho Department of Fish and Game mandatory carcass checks provide the ability to detect changes in sex and age composition of the cougar harvest. These data should be closely monitored in order to guide adjustments in strategies to meet management objectives. To optimize source population effects from

wilderness DAUs, adult female harvest could be reduced through female harvest limit quotas, hunting season changes, limited entry, or other management tools. Opportunities exist to collect and archive DNA from harvested cougars during mandatory checks of hunter-killed cougars. Collection and analysis of DNA to individual cougars, and management of a genetic database, provides a strong tool to assess dispersal and source-sink dynamics on state and region-wide scales.

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## Source-Sink Dynamics and the Recovery of Overexploited Cougar Populations

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**ABSTRACT** The cougar (*Puma concolor*) is a large New World felid that has demonstrated remarkable resilience to anthropogenic impacts, remaining one of the most prevalent large carnivores in North American ecosystems. Presently, cougars are subjected to annual harvests over much of their current range, yet the impacts of sustained hunting on demographic structure and population persistence are not well understood. We have been monitoring two cougar populations in Utah, USA, since 1997. We compared demographic characteristics between an exploited and a protected population to examine the behavioral mechanisms of population recovery and productivity. The treatment population had a younger age distribution, low survival, declining density, and variable fecundity, and generally fit the profile of a sink population. In contrast, the reference population exhibited the opposite trends in nearly every parameter and appeared to act as a source. Under these conditions, sustained exploitation created an ecological trap on the treatment site. Data five years post-treatment suggests that following the implementation of a constant number of permits, the sink population recovered in phases and began functioning as a source. We offer empirical evidence for the occurrence of source-sink dynamics in an exploited cougar population, and argue that in conjunction with the principles of landscape ecology, the source-sink model of population regulation holds promise for the conservation of exploited cougar populations.

## Censusing Pumas by Categorizing Physical Evidence

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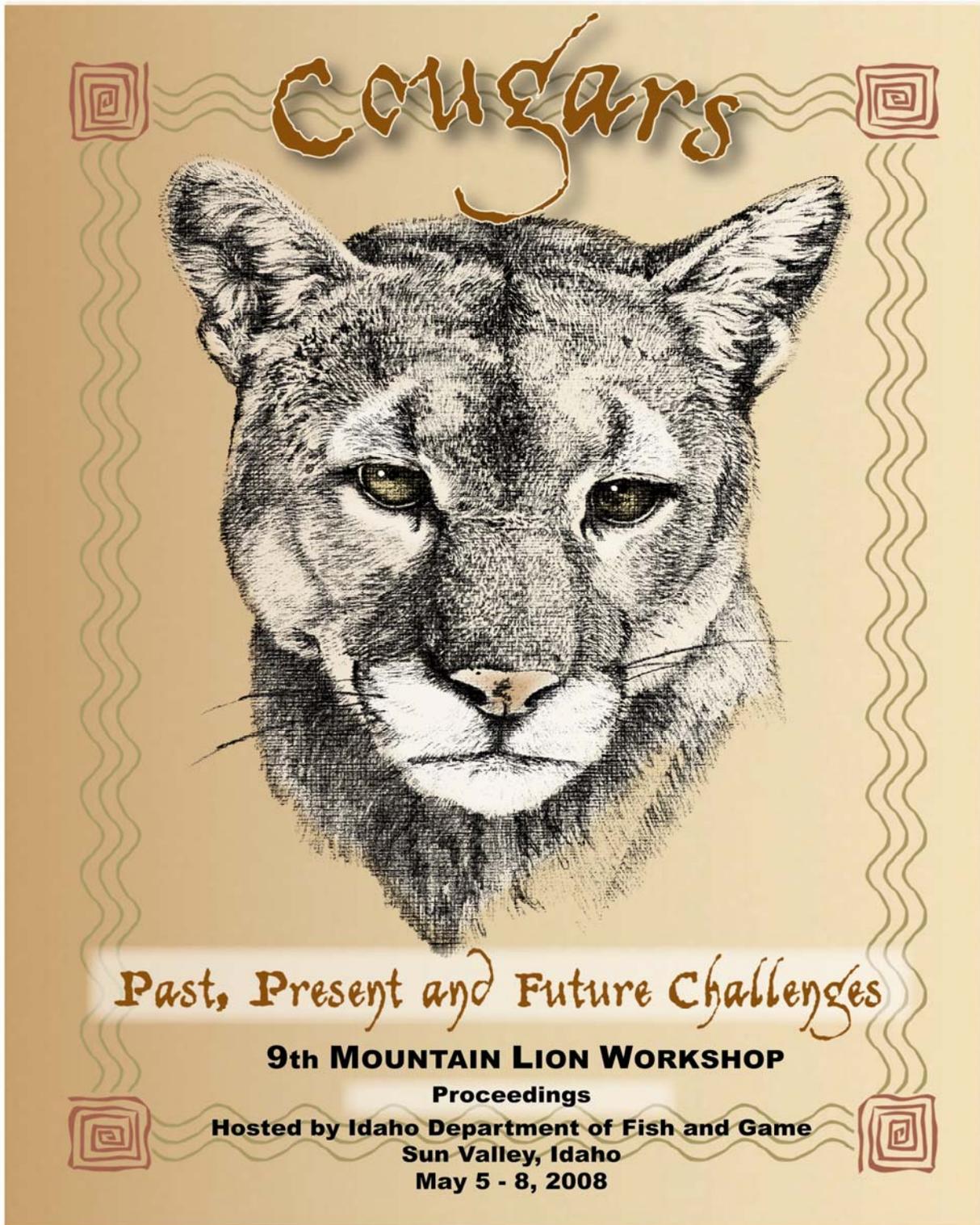
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**ABSTRACT** The occurrence of *Puma concolor* can be confirmed by detecting physical evidence (i.e. tracks, urine markers). However, determining the number of pumas responsible for creating this sign is problematic. We addressed this difficulty by categorizing physical evidence (sign) and tested our method during the *Puma concolor coryi* (Florida panther) project. Three rules were used to distinguish individuals. (1) gender was determined by track size or stride length; (2) time (freshness) was determined by known events within the past 24 hours such as wind or rain; (3) distance between individual track sets was used as an exclusionary tool to avoid overcounting. We verified accuracy by capture and comparison to 3 other indices. This method could be adapted to census other large felines.



# Education and Social Issues



## **Studying Public Perceptions and Knowledge of Cougars in Washington as a Precursor to Outreach and Education Planning**

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**ABSTRACT** Cougar managers are frequently subject to political pressures that are influenced by public perceptions. Consequently, managing cougars increasingly demands a focus on human dimensions. To that end, Washington Department of Fish and Wildlife (WDFW) and Insight Wildlife Management conducted a public opinion survey in Washington in 2008. The objective of the survey was to better understand the public's perceptions of cougar management, identify information gaps, and define effective outreach methodologies. The survey instrument included questions about the ecological role of cougars, cougar behavior, human-cougar conflict, availability of educational materials, and preferred themes for education programs. Using a random sampling telephone survey method, we obtained results from over 800 individuals, and conducted a stratified sub-sample in areas with a higher than average frequency of human-cougar conflicts. We present the results of the survey and compare data from similar surveys in other states. Ultimately, the survey will be used to develop a cougar outreach and education plan for WDFW. We present preliminary ideas for this education plan based upon results from the public opinion survey and other successful carnivore outreach projects.

## **The Land of the Living Dead Comes Alive: The Florida Panther in Big Cypress**

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**ABSTRACT** Ten years ago, a major portion of Big Cypress National Preserve (BCNP), a unit of the National Park Service in south Florida, was described by Florida panther (*Puma concolor coryi*) experts as an area of unsuitable habitat for panthers and their prey. Portrayed as a “population sink”, there was opposition to include BCNP as a reintroduction site in the Florida panther genetic restoration project, which in itself was opposed by some experts in the field. Research and monitoring conducted on both the panther and its prey since then have shown that this 217,000-ha area supports a thriving panther population and that factors other than habitat quality accounted for the scarcity of panthers in the 1980s. With the ongoing development of private lands in south Florida, BCNP and the adjacent public lands are becoming the core habitat remaining for panthers. This paper points up the dangers of premature conclusions when data are scant, especially when it might impact agency decisions on the recovery of an endangered species.

## **Project CAT (Cougars and Teaching)...What the Community Has Learned.**

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**ABSTRACT** Washington Department of Fish and Wildlife began Project CAT (Cougars and Teaching) in collaboration with the Cle Elum/Roslyn school district and local community in 2001. Researchers involve 8 – 12<sup>th</sup> grade students, teachers, and community members in the captures of cougars (*Puma concolor*) from kittens to adult age and monitoring their movement patterns and the spatial organization in the foothills of the North Cascades near Cle Elum, WA. Students have assembled a skeleton of a cougar to learn the bone structure, performed necropsies to learn the anatomy and discover how cougars have died. In the field, students learn to identify tracks and sign of wildlife while accompanying researchers on killsite inspections and captures. They learn about orienteering and using GPS and telemetry. After teaming up with researchers for 7 years, students and teachers share their experiences and what Project CAT has meant to them.

## Science and Education Working Together to Promote Lion Awareness at Grand Canyon

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**ABSTRACT** The theme of the workshop is Cougars: Past, Present and Future Challenges. Future challenges at Grand Canyon National Park include rapid human development and visitation, continued reduction of lion habitat and a growing chance for adverse human-lion interactions. There is a nationwide need for education and awareness about lion behavior, ecology and management. Teaching the general public how and why lions are important can create support for research and science-based lion management. Scientists gather the information, while educators disseminate it.

Eric York, late Grand Canyon biologist, believed that the research and education occurring at Grand Canyon was different than most lion research projects in that research conducted here could be disseminated immediately to a very large audience and that the Park environment offered many unique educational avenues. A successful team has been created between science and education at Grand Canyon NP with the result that the public has received balanced and accurate mountain lion information. Methodologies used to disseminate mountain lion information have included ranger presentations, articles in Nature Notes, web-based videos, special programs to Elderhostel and conservation groups and the creation of site bulletins. Over 10,000 visitors have attended evening ranger programs on current mountain lion research. Our mountain lion web sites have had approximately 13,000 hits since May of 2007 and over 60 Park personnel have been trained by Science Center and Interpretive staff in mountain lion issues. Public support for the program has led the Park Science Center and Interpretive Staff, in conjunction with the Grand Canyon Association, to launch an “Adopt-A-Lion” program which is expected to bring in a significant amount of new funding to support mountain lion research at Grand Canyon National Park.

## A New Paradigm for Partnerships in Cougar Research and Management

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Each biologist must remember the moment when they first knew they wanted to work with wildlife. For many, it was a book or an article they read or a movie they saw. As a ten-year-old girl, the movie, **Born Free**, provided me with the inspiration to work with African lions. Then in 1969, Maurice Hornocker's article in **National Geographic**, *Stalking the Mountain Lion – To Save Him*, was the catalyst that eventually led to my work with America's lions and to a forestry major in college. Those stories were never forgotten and that copy of Nation Geographic was kept. It took many years, but the dream of that young girl became a reality.

This is the power of story. Through stories, we define ourselves and through stories, we make sense of the world.

Each researcher in the field has the power to create a similar impact. Here is a powerful paradigm: the partnership between writers and biologists. Each biologist has the opportunity to help create the story they want the public to hear. Some may want to write their own stories, such as Maurice Hornocker, biologist, Farley Mowat, who wrote **Never Cry Wolf**, and hunter-turned-conservationist, Jim Corbett, who wrote **Temple Tiger** and **Jungle Lore**. Others may want to collaborate with writers to get their story to an audience beyond their peers working in the field.

Too often, there has been an unspoken but uneasy relationship between scientists and nature writers. How many have read Sy Montgomery's **Spell of the Tiger** or David Quammen's **Monster of God**? Writers like Brenda Peterson, Sy Montgomery, Barry Lopez, and David Quammen have, through their writing, provided a template of what this partnership can look like. Public opinion is what drives public policy towards top predators and too often science has been abandoned in the wake of the sensationalized press. By collaborating with writers, scientists can get their story into the public discussion.

Field biologists Gary Koehler and the late Rocky Spencer understood the importance of working with writers. After reading my essay in **Earthlight Magazine** in which I told the story of teaching my children to live in cougar country, the biologists agreed to let me observe and write about their work. As a result of their efforts and willingness to work with writers and reporters, a number of stories about CAT have been published. Articles about Project CAT have appeared locally, regionally and nationally and in each, the project is presented from different perspectives.

On New Year's Day, 2004, the **Yakima Herald** printed a front-page story, beginning with the genesis of Project CAT:

Her dad was a cougar hunter, so Evelyn Nelson grew up with a hands-on understanding of nature's food chain and the mountain lion's place in it. As superintendent of the Cle Elum-Roslyn School District, she wanted her students to have the same kind of experience... It's a unique amalgam of students, scientists, and community volunteers working together in a research and education project.

**WildCat News** published a story I wrote from the students' point of view:

High school senior Rusty Skurski had been learning about the food chain in the classroom. "But," he said, "when I got to go out to a kill site and found an elk carcass, it all started to make sense. Out in the field, you have to search around and try to figure out what happened – what were the movements of the cougar, and what was its reasoning?"

The **Seattle Times** has published two front-page articles about Project CAT. Sadly, the first one was prompted by the untimely death of Rocky Spencer, but, in it they described, in great detail, the cougar research he and Brian Kertson have been doing in Western Washington.

Recently the **Seattle Times** published a front-page article about Project CAT's startling results:

...Studies such as (Ben) Maletzke's question the traditional approach to cougar management. Instead of reducing conflicts between cougars and humans, heavy hunting seems to make the problems worse," says Robert Wielgus, director of Washington State University's Large Carnivore Conservation Laboratory.... Killing large numbers of cougars creates social chaos... Trophy hunters often target adult males, who act as a stabilizing force in cougar populations. These adults police large territories and kill or drive out young males. With the grown-ups gone, the 'young hooligans' run wild."

Project CAT became nationally known when I published an article in **Wildlife Conservation Magazine**. In the article, Gary Koehler explained Project CAT to a national audience.

"Through Project CAT, students gain experience in science and civics. They know what's necessary to maintain both public safety and a healthy population. The students are our colleagues in research, but more importantly, they are the faces and voices of Project CAT. They are the ones who present our findings to the community."

The editor of **Wildlife Conservation Magazine** has said it is the magazine's mission to match biologists with writers so that research discoveries reach the general public.

Partnerships with writers give researchers a freedom they might not otherwise have, as it gives them an opportunity to voice their thoughts and opinions beyond the findings of their research. This may take the form of presenting new ideas whose research is on-

going. By presenting ideas that may be in-progress, the writer takes the risk rather than the researcher.

An example: as a result of the trust established in our collaboration, Gary Koehler and Ben Maletzke told me about their recent observations that indicate mountain lions have a matrilineal society. I asked them if I could write an article about their on-going research and they agreed. I approached my editor at **Wildlife Conservation Magazine** and she accepted the story. Thus by selecting both writer and journal, the biologists were able to target their audience and thereby make certain accurate science was included in the story. Too often the public misunderstands issues facing major carnivores, because a story without scientist input suddenly appears in the media.

Beyond reporting research findings and work-in-progress, writers can also weave in cultural and historical details that give context as to how an animal is perceived.

In India David Quammen worked with biologist Ravi Chellam. In his book, **Monster of God**, Quammen writes about the lions of Gir. In this region, the *Maldhari* are the folks who take care of livestock...

“They don’t own guns. Their battles with the lions approximate hand-to-hand combat. Not safari hunting. Not varmint eradication. Their chief weapon, the kuwadi, is barely more than a short-handled hoe... Rarely does a herder get hurt. Part of being a Maldhari is coping routinely with lions through the use of caution, bluff, and an occasional kuwadi-thunk on the skull.”

For her book, **Spell of the Tiger**, author Sy Montgomery worked with biologist Rathin (Row-teen) Banerjee in Sundarbans (Shunderbun), a giant mangrove swamp formed by the Ganges River as it winds its way into the Bay of Bengal.

“People there have learned how to live in the one area where tigers have clearly demonstrated humans are on their food list. It is through their mythology that some people have learned to co-exist with tigers. Montgomery spoke with a man who had lost both friends and relatives to the tigers. When she asked, “Why not kill all the tigers?” he replied, “To save the earth...” He then explained “...inside the forest of Sundarbans is very costly wood...if the forest is destroyed, the water will wash away the land. It is the work of the tiger to save it. The tigers are our kin, our teachers, and our guardians.” Biologist Banerjee explained, “The tiger is silently doing the work of ecodiscipline.”

By weaving science into a story with both historical and cultural context, an evolution in perspective can occur.

**Never Cry Wolf**, by Farley Mowat, is an example of a story that changed the way a predator is perceived by the public.

From stories, a synergy can begin. In her books, **Singing to the Sound** and **Sightings**,

**The Gray Whales' Migration Journey**, Brenda Peterson describes the divisions between members of the Makah tribe over the hunting of gray whales off the Northwest Coast of Washington state. The press had presented the conflict as a polarized issue between environmentalists and tribal members. Frustrated that other Makah voices were not being heard, Makah elder Alberta Thompson contacted Peterson and then gathered a small group in hopes of discussing the issues at hand.

Thompson, a 75 year-old woman, spoke for those elders who opposed the tribal council's push toward renewed whaling. As the group ventured out into the open waters of Neah Bay, they included elder Thompson, writer Peterson, marine biologist Toni Frohoff, a Makah Tribal Council member and a Whales Alive environmentalist. Once out on the water, biologist Frohoff began to describe the whale migration patterns.

Gray whales began to surface and approach the small boat. The environmentalist turned to the Makah council member, and said, "No one knows this land and these waters like the Makah. You have a cultural history with the whales that would give your whale watching more dimension than just a business venture."

The Makah man listened and then looked out over the land and water he called home and, as Peterson described, "His face lit up. He said, 'Can you just see it? Can you just see a boat full of Makah kids meeting the whales?'"

So, as we find our way in this new millennium, we must remember to bring our story tellers with us. But the choice is up to each scientist. Certainly the mountain lion's story can continue to be told as, to use Quammen's words, "predator pornography" with snarling jaws and exposed teeth, alternately biologists can take the lead and, through partnership with writers, tell the stories they want to be told about mountain lions.

## **9<sup>th</sup> Mountain Lion Workshop**

### **Panel Discussion Participants, Questions, and Response Summary**

#### Panelists:

Howard Quigley, Executive Director, Craighead Beringia South

Terry Mansfield, Deputy Director (retired), Idaho Department of Fish and Game

Gary Power, Commissioner, Idaho Fish and Game

Gary Koehler, Wildlife Research Scientist, Washington Department of Fish and Wildlife

Steve Nadeau, Large Carnivore Manager, Idaho Department of Fish and Game

Linda Sweanor, Interim President, Wild Felid Research and Management Association (WFA)

#### Questions for Panel Discussion

- 1) In the case of continued human urbanization and development in cougar habitat, how can cougar managers better integrate awareness on multiple planes... such as land-use planning entities, developers, and the general public?
- 2) Where do we get the funding to accomplish long-term studies that have the scientific robustness to affect management and answer our ecological questions?
- 3) Is it worth considering development of multi-agency, multi-state approaches to deal with conflicting values, opinions and viewpoints that result in conflict-driven management? What educational approaches at state or regional levels might be considered?
- 4) Given that harvest trends are remarkably consistent across the West, how do you explain the apparent disassociation with widely varying hunting season frameworks?
- 5) Given the consistent trend in declining harvest in most western states, how will this influence future management and harvest opportunities?
- 6) How can states standardize DNA collection to have regional, and even continental, application?
- 7) Would it be best to have a central depository, or bank, for both disease and genetic information, and is the Wild Felid Association a good managing entity for this?
- 8) If you want to reduce the cougar population in a management unit, can it be effectively done through established harvest limits, or does that just alter the age structure?
- 9) What is the best method for integrating source-sink dynamics into cougar management plans that can stay “current” with annual population changes?
- 10) Should cougar range expansion into new regions, such as the Mid-West, be encouraged or discouraged from a social acceptance standpoint? What is the likelihood of these dispersal trends (especially from the Black Hills) continuing, given changes in Western cougar populations? Given our experiences in the West, what is the likelihood of cougar acceptance in the Mid-West?

- 11) How do we manage real-time GPS data, and do we provide this information to the public?
- 12) (Audience) Are cougars getting less management attention since wolves are getting, and needing, so much of the carnivore manager's time?

#### Question Response Summary (Main Themes, Concerns, and Responses)

- ❖ Theme: How can we integrate cougar awareness with current rates of urbanization and loss of habitat?
  - Concern: Can cougar “danger awareness” be integrated into the land-use planning process?
  - Responses: Cougar managers have an ever-increasing responsibility to get involved in planning activities and to articulate the consequences and educational needs that come about when occupied cougar habitat is converted to residential and urban areas.
  
- ❖ Theme: A need exists for a genetic bank for cougar DNA and disease pathology having national coverage.
  - Concern: Who would manage such a repository?
  - Responses: Either a University with a well-established genetic lab or a Non-Governmental Organization (NGO). The Wild Felid Research and Management Association would be best suited to coordinate a genetic bank. Samples can be effectively taken using bio-darts, such as in Washington State, and mandatory check-in of hunter-harvested cougars such as those that are applied in most western states for collection of biological samples. Strict guidelines on data usage and data sharing are needed, or there may be low willingness to participate for fear of unauthorized use of data.
  
- ❖ Theme: Integrating cougar research with management plans and actions.
  - Concern: There is not enough communication between the scientific community doing cutting-edge research and decision making agency managers and commissioners.
  - Responses: Researchers need to stay active and provide the latest knowledge and technology to decision makers like Fish & Game Commissioners and State Directors/Deputy Directors. The Wild Felid Research and Management Association were developed to provide a forum to enhance communication between researchers and managers, as well as a forum for sharing cutting edge techniques.
  
- ❖ Theme: Can current knowledge of source-sink dynamics be applied when establishing cougar harvest guidelines.
  - Concern: The current structure for harvest does not adequately consider our knowledge of source-sink dynamics for cougar populations.
  - Responses: This knowledge does get applied in some states, for instance in Wyoming. Better state-to-state communication, and sharing of genetic and other biological information, will help greatly toward achieving management

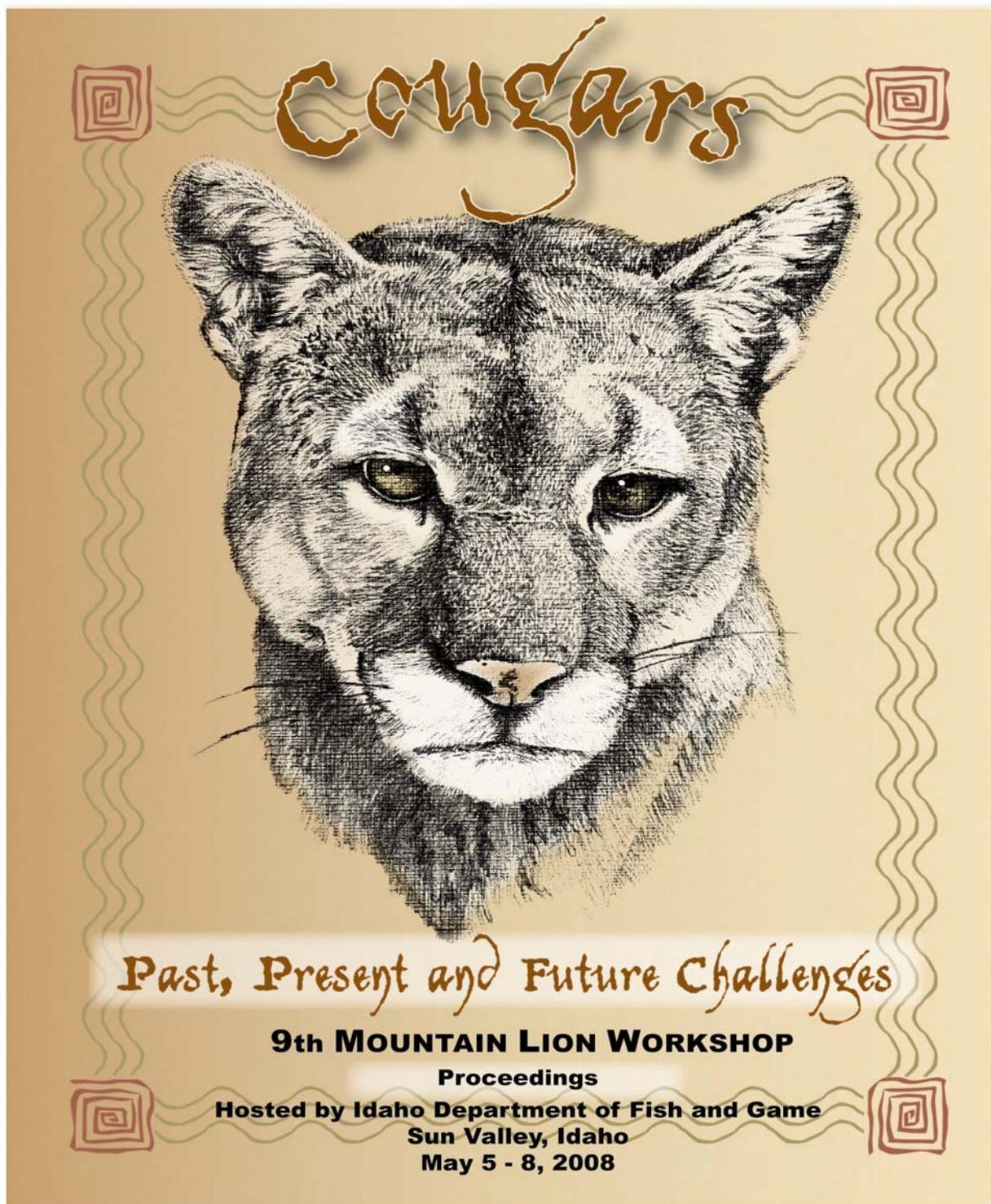
programs that apply source-sink concepts. However, concepts would have to be applied differently by each state as each state has different assets. For instance Idaho has a very large wilderness, a defacto source population and other states do not have similar conditions.

- ❖ Theme: (audience generated). Since wolves have become established in several western states, are state agencies giving enough attention to the management, and population monitoring needs for cougars?
  - Concern: High levels of wolf management is distracting from cougar management with most state agencies having these resources shared within one carnivore program.
  - Responses: Idaho, Montana, and Wyoming are all facing this man-power dilemma with both wolves and cougars now having a widespread geographic distribution. Regional staff will have to assume more problem responsibility, and situation prioritization will need to be applied, which favors human safety and protection of personal property (such as livestock and personal pets) where these may be at risk.
  
- ❖ Theme: Recent evidence supports the range expansion of cougars into various mid-western states.
  - Concern: Is there a mechanism for tracking this range expansion, and means to identify where the source populations are located? Is this expansion socially acceptable?
  - Responses: Two methods to track this expansion are: validating sightings; (a current mission of the group called “The Cougar Network”) and through scientific data collection, with a nation-wide genetic bank that is managed by a reputable entity such as the Wild Felid Association. Social acceptance will involve a major educational effort that will need to come from state agencies (not there yet) and from reputable NGO’s.
  
- ❖ Theme: Given that harvest levels on cougars are on a downward trend across the west, how can such a downward trend be explained in light of widely varying hunting season frameworks and range expansion?
  - Concern: How will a declining population trend in most western states influence future management and harvest opportunity?
  - Responses: It was widely felt that declining prey populations (deer, elk) were contributing to cougar population declines in the West. Such declines on a local scale may cause cougars to explore new areas, lending to range expansion. Declining cougar populations may also be due to more liberal harvest opportunities in most western states. It was expressed that the lower numbers of cougars were might reduce cougar-human conflicts, a potentially positive result on the urban fringe. Cougar population trends however were similar in many states despite variation in harvest regimes from high to no harvest. Population estimates and harvest reflected peaks during the mid to late 1990’s followed by a decline until recent years where many states show a leveling off in the population. These trends ranged from Idaho where harvest seasons were made more lenient during the last decade, to California where

harvest is not allowed. This reflects some regional trend more so than state by state regulations. Additionally, it was felt that even with lower cougar numbers, predation effect on ungulates in areas with wolves in the system was equal to or greater than, predation rates when cougar numbers were higher. At this time no western states have a wolf hunting season, although multiple states are pressing for this management tool. Finally, it was asked the panel if cougar numbers will ever be at “maximum potential” in places where they co-exist with wolves. The general response from the panel was: “probably not, and time will tell.”



# Key Concepts: Mountain Lion Management



## **Implications of Sink Populations in Large Carnivore Management: Cougar Demography and Immigration in a Hunted Population.**

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**ABSTRACT** Carnivores are widely hunted for both sport and population control especially where they conflict with human interests. How carnivore populations respond to harvest can vary greatly depending on their social structure, reproductive strategies, and dispersal patterns. If carnivore management plans (both sport harvest and population control) do not take into account the specific response of individual species to harvest, the plans may be detrimental to the greater population, or ineffective for local population control. Hunted cougar populations have shown a great degree of resiliency, due to high immigration and recruitment, and have sustained annual harvest levels of 15-30 % of resident adults. Although hunting cougars on a broad geographic scale ( $>2,000 \text{ km}^2$ ) can reduce cougar densities, hunting of small areas (i.e., Game Management Units  $<1000 \text{ km}^2$ ) as currently prescribed by many game management agencies, may lead to the establishment of metapopulation source/sink dynamics. We tested the effects of heavy hunting at a small scale ( $<1,000 \text{ km}^2$ ) to gauge whether population control was achieved ( $\lambda \leq 1.0$ ) or if hunting losses were negated by increased immigration allowing the population to remain stable ( $\lambda = 1.0$ ) or increase ( $\lambda \geq 1.0$ ). The real growth rate of 1.00 was significantly higher than modeled growth rates (deterministic 0.89 and stochastic 0.84), with the difference representing an 11-16% annual immigration rate. We observed more juveniles in the population than predicted by the stable age distribution, no decline in the total or adult population density, and a significant decrease in the average age of independent males. Our data support the compensatory immigration sink hypothesis: cougar removal in small game management areas ( $<1,000 \text{ km}^2$ ) will increase immigration and recruitment of younger animals from adjacent areas, resulting in little or no reduction in cougar densities and a shift in population structure toward younger animals. Metapopulation source/sink dynamics between areas with disparate harvest levels can complicate management objectives by maintaining populations in heavily hunted sink areas through immigration, while possibly masking declines in source populations. We suggest that broad-scale population reductions of predators or local prey reductions may be necessary for local population control of cougars and other carnivores.

## **Dispersal Movements of Subadult Cougars from the Black Hills of South Dakota and Wyoming: Concepts of Range Edge, Range Expansion, and Repatriation.**

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**ABSTRACT** Dispersal plays a vital role in cougar (*Puma concolor*) population ecology, increasing genetic viability and maintaining gene flow between populations. The Black Hills cougar population is at the eastern edge of cougar range in North America and completely surrounded by the Northern Great Plains. In addition, the population rebounded from practical extirpation to that of a flourishing breeding cougar population within the 20th century. Because of the semi-isolated nature of the re-established cougar population, we wanted to document dispersal movements of subadult cougars captured within the Black Hills ecosystem. Subadult cougars were captured during the winters of 2003-2006, fitted with VHF radio-transmitters, and monitored weekly. Locations were plotted in ArcGIS and dispersal distances calculated from capture point/natal home range to: site of death, last known location, or post-dispersal home range centerpoint. Kittens were captured by hand from radioed females to document age of independence and dispersal. A total of 29 subadult cougars were captured in the Black Hills (n=19 males, n=10 females). Cougars reached independence an average of 13.5 months from parturition; with dispersal occurring 1-3 months post independence. Males dispersed (mean = 302.5 km; range: 29.9-1,067.0 km) farther than females (mean = 48.5 km; range 12.5-110.1 km). Female cougars exhibited 40% philopatry, with no successful recruiting of subadult males to the Black Hills population. We documented several (n=5) long distance dispersal movements (>250 km) by male cougars and suggest that males making long-distance movements were in essence seeking an available mate. Dispersal movements away from the study area crossed atypical cougar habitat (i.e., prairie/grassland, agricultural and interstate highway systems). Our results suggest that cougar population connectivity, range expansion and habitat repatriation are occurring across North America. Furthermore we suggest that agencies react proactively to cougar movements and increase public knowledge of cougar ecology in areas where cougars have been devoid for long periods.

## **Formation of a Professional Organization: the Wild Felid Research and Management Association**

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**ABSTRACT** Participants expressed an interest in the formation of a new professional association on wild felids in a survey given at the Eighth Mountain Lion Workshop held in Leavenworth, Washington, USA in May 2005. As a consequence, 10 people with a mix of experience in felid research, management, and conservation met in Bainbridge, Washington in August 2006 to create the Wild Felid Research and Management Association, or WFA. Together, we structured the WFA to be a professional, non-advocacy organization of biologists, wildlife managers, wildlife educators, and others who are dedicated to the management and conservation of wild felids in the Western Hemisphere through science-based management and education. In this presentation I discuss the results of the Mountain Lion Workshop Survey, outline the need for a professional wild felid organization, and present the objectives of the newly formed Wild Felid Research and Management Association. I will also present an update on the present status of the WFA, including its organizational structure, the publication of the first issue of the WFA's newsletter: the Wild Felid Monitor, the development of the WFA web site ([www.wildfelid.org](http://www.wildfelid.org)), and the characteristics of the current membership. This association's main objective is to facilitate communication and collaboration across scientific disciplines and among agencies, universities, and nongovernmental organizations. The newsletter and web site are 2 ways the WFA will achieve this objective. As the WFA develops, we hope to provide other services, including counsel and advice on policy issues, translations of technical information into popular literature and other media, conferences, workshops, and peer-reviewed proceedings, and scholarships and grants for felid research, management and education. Because the development of these tools and services will require further involvement by a voting membership, I will end the presentation with a discussion of WFA's current needs, including how interested persons can help advance the professional goals of this organization and help best meet the needs of its membership.

## **Cougar Management Protocols: a Survey of Wildlife Agencies in North America**

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Wildlife agencies face a formidable task when managing cougar (*Puma concolor*). Unlike many other large mammalian species, long-term research studies investigating the ecology and natural history of cougars are relatively limited and a reliable, affordable method for enumerating cougar populations has not been reported in the literature. Throughout their range, the legal status of cougars varies greatly including: federally listed as endangered (FL, USA); specially protected mammal (CA, USA); protected game species (most western jurisdictions, USA and Canada) and unprotected (TX, USA and MX). Many wildlife agencies in the West also manage cougar populations to help meet management objectives of other species (e.g., bighorn sheep (*Ovis* spp.), mule deer (*Odocoileus hemionus*), and elk (*Cervus elaphus*). These challenges are further complicated by the highly social-political charge of cougar issues. Confounding all of these biological, social, and political issues is the lack of adequate funding to meet these challenges. With increasing human populations and diminishing habitats, the amalgamation of managing these factors will become more imperative in the future. For these reasons, it is critical that researchers and managers regularly communicate cougar management successes and limitations in an effort to help refine and enhance cougar management protocols across the species' range. The objective of our survey was to compare cougar management protocols throughout North America so agencies could benefit from the experiences of other jurisdictions and more readily update their own management protocols. Our information builds on prior survey/questionnaire work (Anonymous 1984, Green 1991, Tully 1991, Dawn 2002).

### **Methods**

We surveyed wildlife agencies that manage cougar in North America, including 15 States in the USA (AZ, CA, CO, FL, ID, MT, NM, NV, ND, OR, SD, TX, UT, WY, WA), 2 Canadian Provinces (AB and BC), and 5 jurisdictions in Mexico. States where cougar presence has been documented but have no known viable cougar populations were not contacted (AR, IA, MN, MO, NE, OK). The self-administered Internet survey (SurveyMonkey, Portland, Oregon, USA) consisted of 47 questions regarding cougar management plans, population status, database management, cougar-human conflict, public safety, capture-relocation, and public education (Appendix A). For the analysis, we converted all responses to numerical scores. Multiple-choice scores were treated as

nominal data, yes/no scores as dichotomous data, and ranked scores as ordinal data. The SurveyMonkey tool allowed agencies to complete the survey in one visit or in multiple revisits, saving their responses to date.

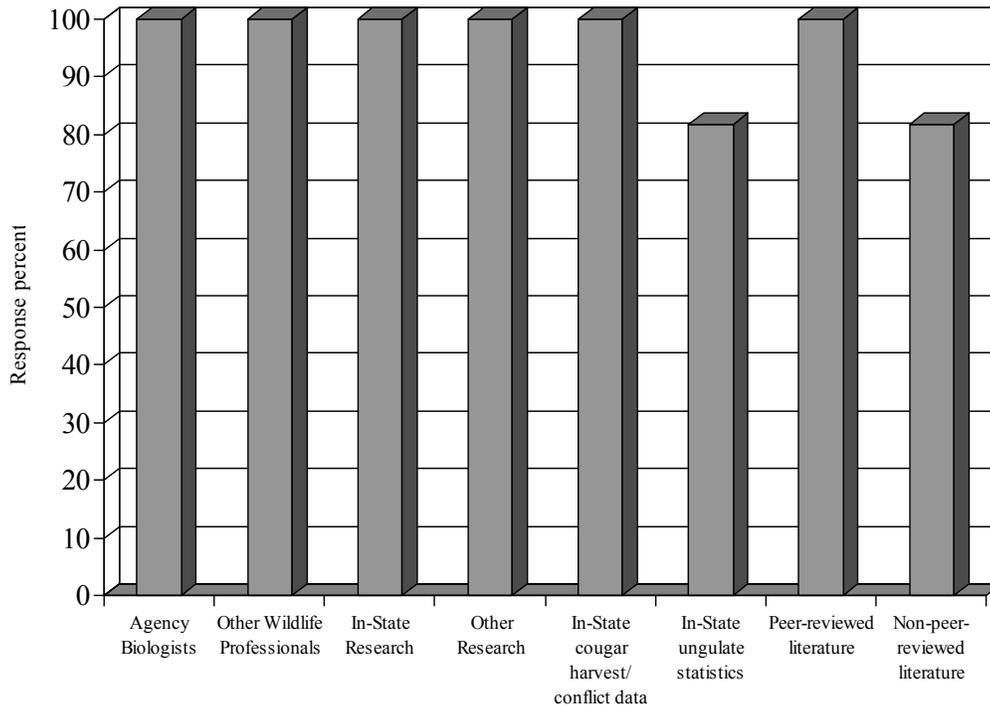
For comparison purposes, we report some of the responses by region (northwest = Alberta, Idaho, Montana, Oregon, Washington, Wyoming; southwest = Arizona, California, Colorado, New Mexico, Nevada, Texas, Utah). We also compared results by season; we identified them as spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

Currently, Mexico does not have an agency or specific entity dedicated to cougar management (John Laundré, personal communication). Therefore, with the assistance of Mr. Laundré, we surveyed researchers in various portions of that country and used their input for representation of Mexico. Ultimately, we felt the responses from Mexico were too localized and, because questions were geared towards managers, not as representative as other jurisdictions. Given this disparity, we discussed results obtained from Mexico where applicable but censored them from agency comparisons and group results.

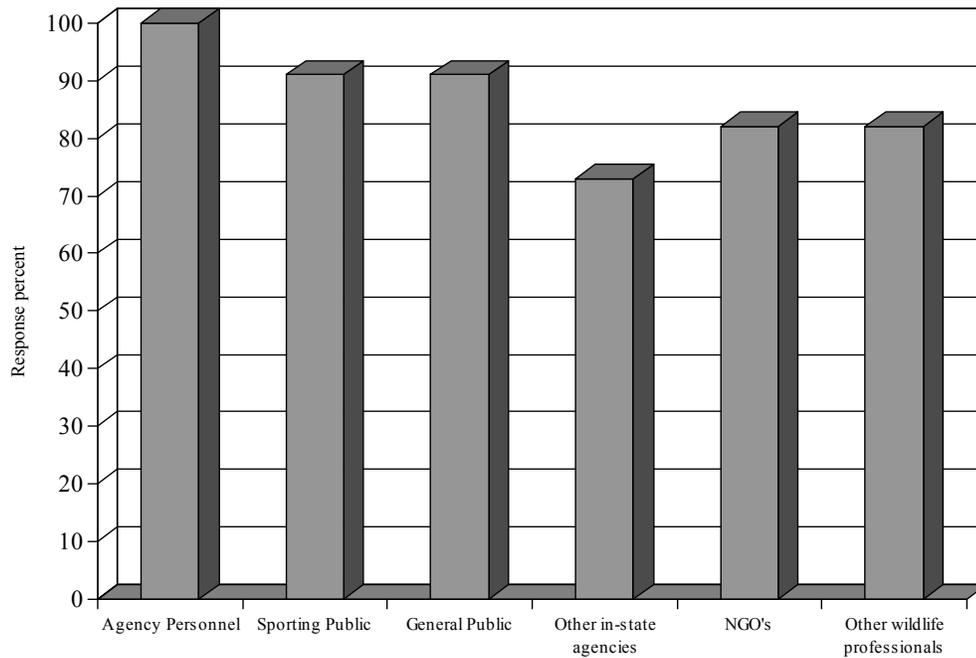
## **Results**

### **Cougar Management Plans**

We received completed surveys from 14 States, 1 Province, and 5 researchers in Mexico. Of the 15 responding agencies, 11 (73%) had established cougar management plans and 4 did not (27%; this includes Florida which operates only under the federal endangered policy) (Table 1). Agencies utilized a variety of resources when developing cougar management plans including harvest statistics of cougars and ungulates, field research, literature, and input from biologists and other wildlife professionals (Fig. 1). In most cases, biologists (91%) were primarily responsible for writing cougar management plans, but in several jurisdictions, it was a partnership with managers (64%); only Nevada mentioned that their Game Commission and County Commission Boards helped write management plans. To solicit comments during management plan development, agencies conducted public meetings (91%), provided requested drafts (82%), and made plans available online (46%). Once a plan was developed, agencies sought input from a varied audience (Fig. 2). Agencies cited many factors that influenced change to their cougar management plans (Table 1); 100% of agencies with a management plan said social factors influenced change; followed by updated scientific information (91%), political factors/legislation (91%); changes in harvest structure of cougar (73%), and ungulates (73%). Of the 11 jurisdictions that had cougar management plans, 4 updated their plan every 7-9 years (36%), 3 updated their plan every 10+ years (27%), 3 updated their plan every 4-6 years (27%), and 1 updated their plan every 1-3 years (9%) (Table 1). Mexico does not currently have a cougar management plan in place.



**Figure 1.** Sources of information used in creating cougar management plans, as reported in a survey of North American wildlife agencies, 2008.



**Figure 2.** Stakeholders providing comments to cougar management plans, as reported in a survey of North American wildlife agencies, 2008.

## Population Status

Of the 15 responding agencies, 12 (87%) said obtaining cougar population estimates was a priority given their agency's current management needs (Table 2). Eleven agencies (73%) said they have at least a rough estimate of cougar populations in their state/province (Table 2). The estimated total cougar population summed across all jurisdictions ranged from 24,850-31,375 (6 jurisdictions did not report). The most common way agencies estimated cougar populations across all jurisdictions was extrapolation of hunter harvest data (67%), followed by field research (47%), and habitat assessment and extrapolation using densities reported in literature (40%) (Table 3). Agencies (86%) estimated cougar populations on a statewide basis, or throughout occupied range. Most agencies updated population estimates every 1-3 years (50%), followed by 4-6 years (21%) and 7 years or more (64%) (Table 1). Agencies said population estimates were used primarily for informational purposes (69%) and to adjust sport harvest quotas (69%); 54% of agencies said population estimates were used to evaluate management decisions and to refine their cougar management plan (Table 4).

In Mexico, researchers estimated the cougar population at approximately 2,000 animals. The most common method of estimation was track transects and habitat assessment using GIS (Chihuahua, Coahuila, Durango, and Sonora regions) followed by mark-recapture studies (Chihuahua, Oaxaca, and Sonora regions).

**Table 1.** Cougar management plan status, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

Jurisdiction	Mgmt. Plan in Place?	How often is Plan Updated?	What Influences Change in Management Plan					
			Updated Science	Harvest Structure	Ungulate populations	Social Factors	Political Factors	NGO Input
Alberta	Yes	10+ years	X			X	X	
Arizona	No							
California	Yes	10+ years				X	X	
Colorado	Yes	7-9 years	X	X	X	X	X	X
Florida	No <sup>1</sup>							
Idaho	Yes	10+ years	X	X	X	X	X	X
Montana	No							
Nevada	Yes	7-9 years	X		X	X		
New Mexico	Yes	4-6 years	X	X	X	X	X	X
Oregon	Yes	4-6 years	X	X	X	X	X	X
South Dakota	Yes	1-3 years	X	X		X	X	X
Texas	No							
Utah	Yes	7-9 years	X	X	X	X	X	X
Washington	Yes	4-6 years	X	X	X	X	X	X
Wyoming	Yes	7-9 years	X	X	X	X	X	X

<sup>1</sup>Managed under Endangered Species Act

**Table 2.** Cougar population status by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Estimated Population</b>	<b>How Often Are Estimates Updated?</b>	<b>Is it a Priority to Obtain Population Estimates?</b>
Alberta	800-1,200	1-3 years	Yes
Arizona	1,500-2,500	1-3 years	Yes
California	4,000-6,000	Not often	No
Colorado	3,000-3,600	4-6 years	Yes
Florida	<150	1-3 years	Yes
Idaho	2,000	When info changes	Yes
Montana	Unknown	No estimate	Yes
Nevada	2,500	1-3 years	Yes
New Mexico	2,000-3,000	4-6 years	Yes
Oregon	5,700	1-3 years	No
South Dakota	200-225	1-3 years	Yes
Texas	Unknown	1 <sup>st</sup> in 20 years	Yes
Utah	Unknown	1-3 years	Yes
Washington	1,000-2,500	1-3 years	Yes
Wyoming	Unknown	No estimate	No

**Table 3.** Method used to derive cougar population estimates, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Extrapolation of hunter harvest</b>	<b>Track Transects</b>	<b>Field Research</b>	<b>Habitat Assessment/ Extrapolation Using Densities in Literature</b>	<b>No Estimate</b>
Alberta	X			X	
Arizona	X		X	X	
California				X	
Colorado				X	
Florida		X	X		
Idaho	X				
Montana					X
Nevada	X			X	
New Mexico	X		X	X	
Oregon	X			X	
South Dakota	X	X	X	X	
Texas <sup>1</sup>	X				
Utah	X		X		
Washington	X		X	X	
Wyoming	X		X	X	

<sup>1</sup>Genetic research resulting in a net effective population estimate

**Table 4.** Agency use of cougar population estimates, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Used for Information Purposes</b>	<b>Used to Refine Cougar Management Plan</b>	<b>Used to Adjust Sport Harvest Levels/Quotas</b>	<b>Used to Evaluate Management Decisions Regarding Ungulate Populations</b>
Alberta			X	
Arizona			X	X
California	X			
Colorado	X	X	X	
Florida	X			
Idaho	X			
Montana <sup>1</sup>				
Nevada	X	X	X	X
New Mexico	X	X	X	X
Oregon		X	X	X
S. Dakota	X	X	X	
Texas	X			
Utah	X	X	X	X
Washington	X	X	X	X
Wyoming <sup>1</sup>				

<sup>1</sup>No estimates made

### **Cougar Database Management**

When asked what type of information is collected from hunter harvest, 87% of agencies reported they collect gender, kill date, and kill location, 80% collected the number of licenses sold, hunter effort, and kill type (i.e., modern firearm, archery, etc), and 73% collected a tooth or estimated the age class of the cougar killed (Table 5). Thirty-three percent of agencies recorded body condition, 27% collected gum line recession, and 1 agency (7%) recorded lactation status of females.

When asked what type of information is collected on depredations, 14 agencies provided a response. Of those, 100% recorded the number of annual depredations, 93% collected date and location, and 86% collected gender and age of cougar involved (if dispatched), and 50% collected information on the contributing factors that may have led to the depredation (i.e., feeding wildlife, husbandry practices, free-ranging livestock, etc.) (Table 6). Sixty-seven percent of agencies recorded sighting information (i.e., date and location) but only investigated them if it was an issue of public safety.

In Mexico, researchers kept a localized database on hunting mortality (gender, kill date, kill location, and kill type) and depredations (date, location, contributing factors, gender if killed, and species attacked) in the Jalisco and Oaxaca regions.

**Table 5.** Responses to what information is collected for agency database on cougar mortalities, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008

<b>Information Collected on Cougar Hunting and Cougar Mortalities</b>														
<b>Jurisdiction</b>	<b>Annual # Kills</b>	<b># Licenses Sold</b>	<b># Hunters in the Hunter Effort</b>	<b>Gender of Kill</b>	<b>Date Of Kill</b>	<b>Age (or Class) of Age –Tooth</b>	<b>Age – Cementum</b>	<b>Age – Gum</b>	<b>Body Condition</b>	<b>Location of Harvest</b>	<b>Location - per hunt</b>	<b>Location - per region</b>	<b>Weapon type (i.e., archery modern firearm, archery, ...)</b>	<b>Kill type (i.e., road kill, hunt kill, landowner kill.</b>
Alberta													X	X
Arizona														X
California <sup>1</sup>														X
Colorado													X	X
Florida <sup>1</sup>														X
Idaho														
Montana <sup>2</sup>													X	X
Nevada <sup>3,4</sup>													X	X
New Mexico														X
Oregon														
South Dakota <sup>5</sup>														X
Texas														
Utah													X	X
Washington <sup>3</sup>													X	X
Wyoming													X	X

<sup>1</sup>Hunting not allowed

<sup>2</sup>Mentioned collecting lactating status

<sup>3</sup>Mentioned collecting DNA

<sup>4</sup>Mentioned collecting stomach contents

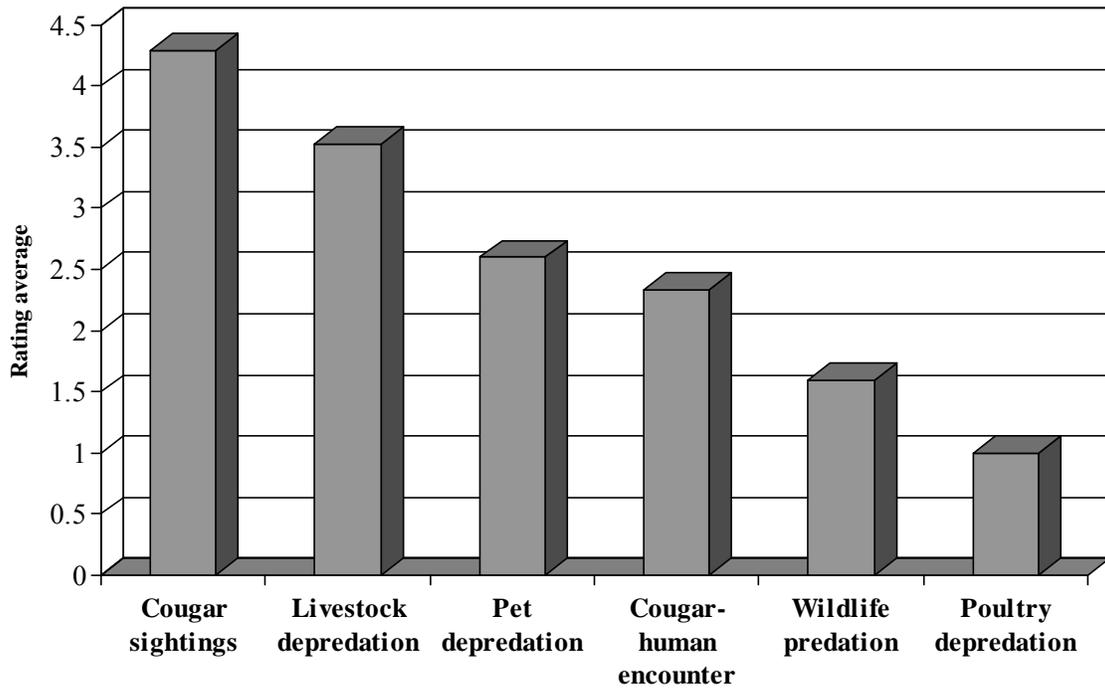
<sup>5</sup>Mentioned collected body measurements

**Table 6.** Responses to what information collected on cougar depredations, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

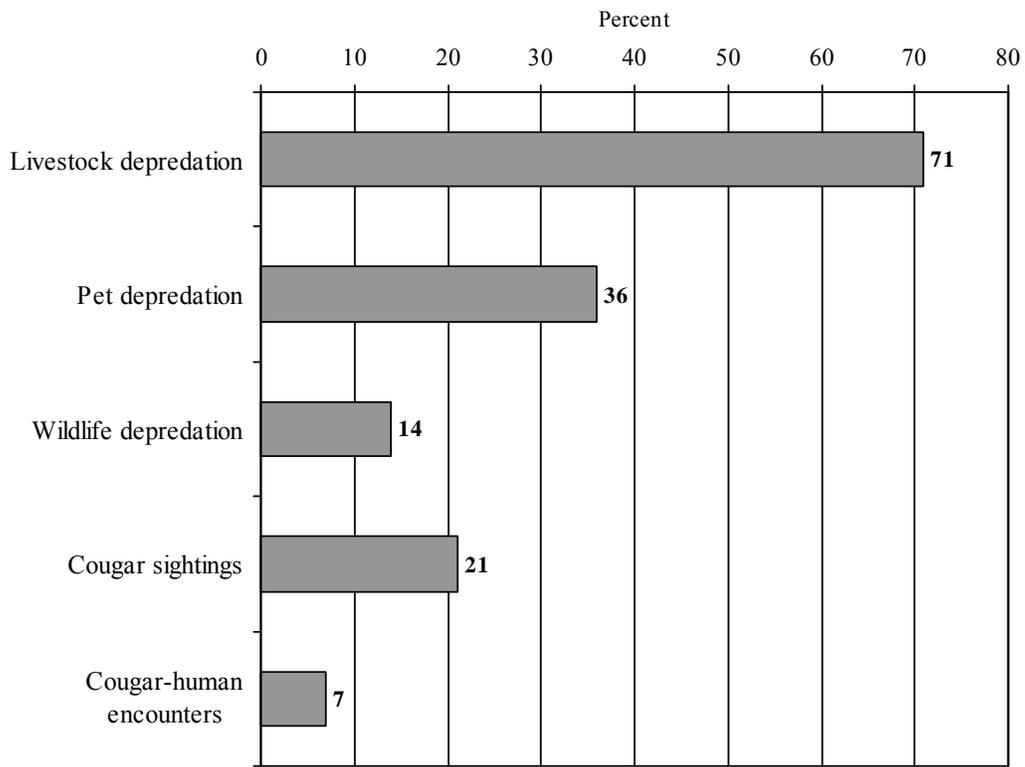
<b>Information Collected on Cougar Depredations</b>							
<b>Jurisdiction</b>	<b># Annual Depredations</b>	<b>Location of Depredation</b>	<b>Date of Depredation</b>	<b>Gender information (if cougar is dispatched)</b>	<b>Age Assessment (if cougar is dispatched)</b>	<b>Possible Contributing Factors of Depredation</b>	<b>Species of animal attacked or killed</b>
Alberta			X	X	X	X	X
Arizona			X	X	X		X
California			X	X	X	X	X
Colorado			X	X	X		X
Florida			X			X	X
Idaho			X	X	X		
Montana							
Nevada			X	X	X	X	X
New Mexico			X	X	X		X
Oregon			X	X	X		X
South Dakota			X	X	X	X	X
Texas							
Utah			X	X	X		X
Washington			X	X	X	X	X
Wyoming			X	X	X	X	X

### **Cougar-human Conflict**

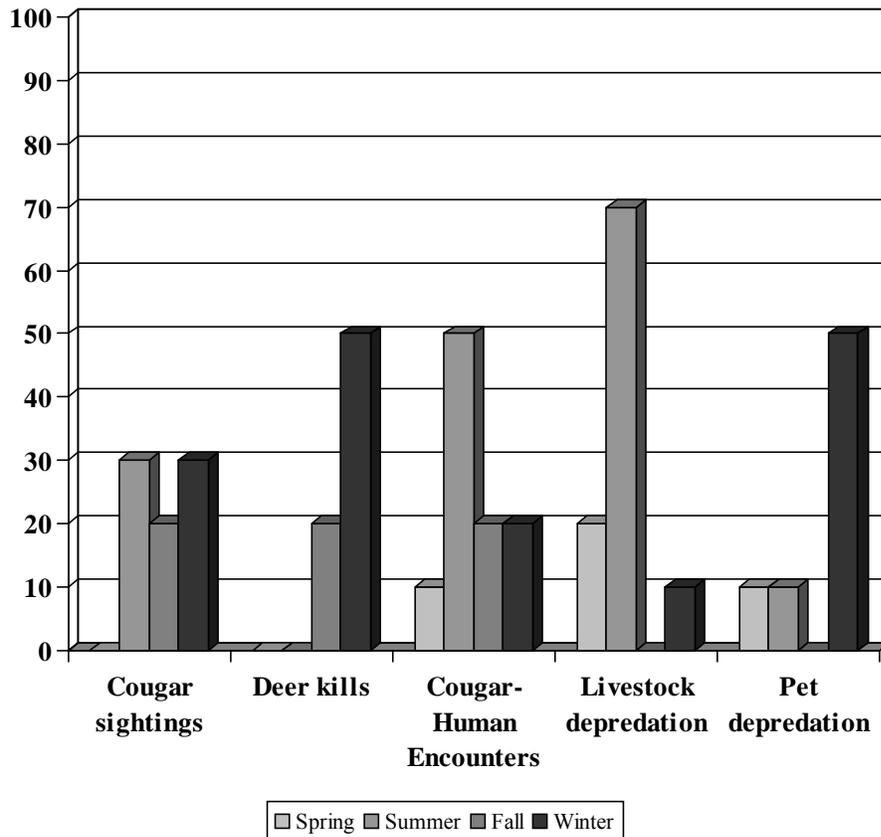
Agencies reported that sightings were the most common type of cougar-human conflict, followed by livestock depredation, pet depredation, human encounters, wildlife predation, and poultry depredation (Fig. 3). When asked which conflicts were considered common to serious problems, livestock depredation rated highest (71%) followed by pet depredation (36%), cougar sightings (21%), wildlife predation (14%), and cougar-human encounters (7%) (Fig. 4). Questions regarding the time of year cougar-human conflicts occurred yielded mixed results: across all jurisdictions, cougar sightings occurred most often in summer and winter; reports of wildlife predation was most common in fall and winter; human encounters occurred throughout the year but showed a significant spike in summer; livestock depredation was most common in summer; and pet depredation was most common in winter (Fig. 5).



**Figure 3.** Mean Ranking of cougar-human interactions in order of occurrence (6=most common to 1=least common), as reported in a survey of North American wildlife agencies, 2008.



**Figure 4.** Percent of agencies who thought these cougar-human conflicts were common to serious problems, as reported in a survey of North American wildlife agencies, 2008.



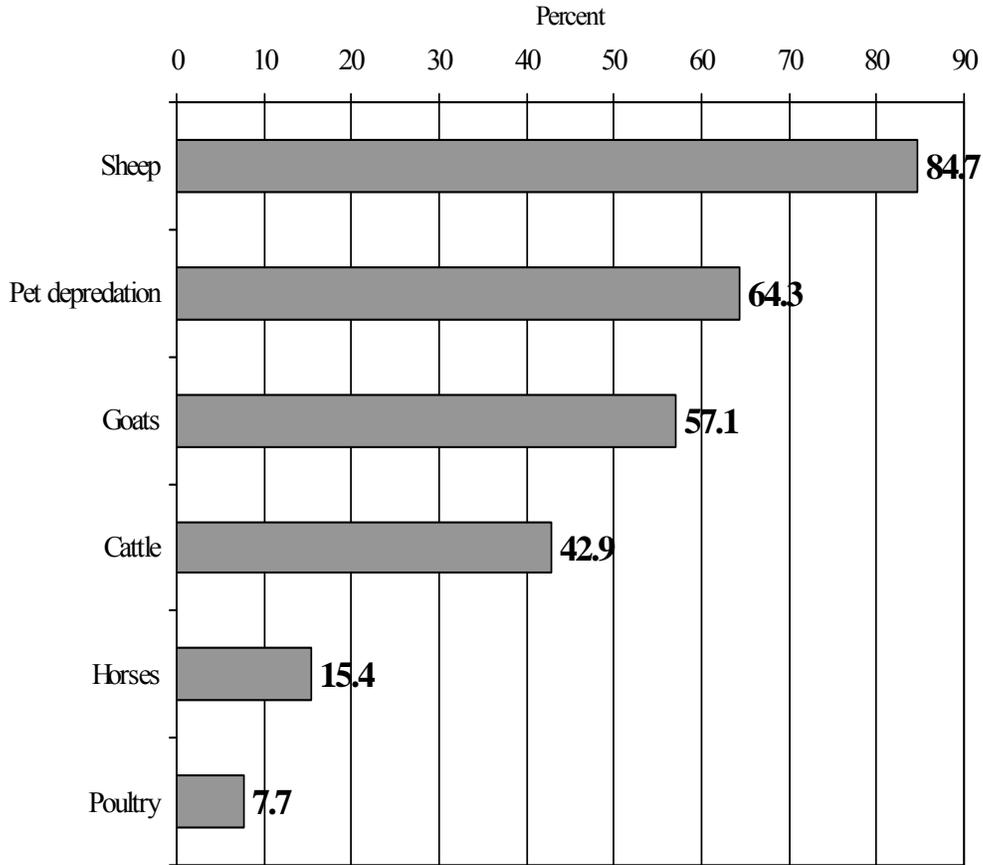
**Figure 5.** Cougar-human interaction types, by season, as reported in a survey of North American wildlife agencies, 2008.

Throughout the US and Canada, approximately 1,018 cougar depredations occurred per year (excluding Utah) (Table 7). When analyzed on a regional basis: northwest jurisdictions reported 643 depredations; 368 occurred in southwest jurisdictions; and 7 occurred in southeast. We provided a list of common species involved in depredation and asked agencies to rank them in their jurisdiction (multiple choice answers). Across all jurisdictions, sheep were most commonly involved in cougar depredations (85%), followed by pets (64%), goats (57%), cattle (43%), horses (15%), and poultry (8%) (Fig. 6). When analyzed on a regional basis, northwest jurisdictions reported pets, sheep, and goat depredation as most common species, southwest states reported sheep, cattle, and pet depredation as most common, and in the southeast, Florida reported goats, pets, and fowl depredation as most common, respectively.

**Table 7.** Average number of cougar depredations per year (in the past 5 years), depredation ranking, and when depredations are most common, by jurisdiction, as reported in a survey of North American wildlife agencies.

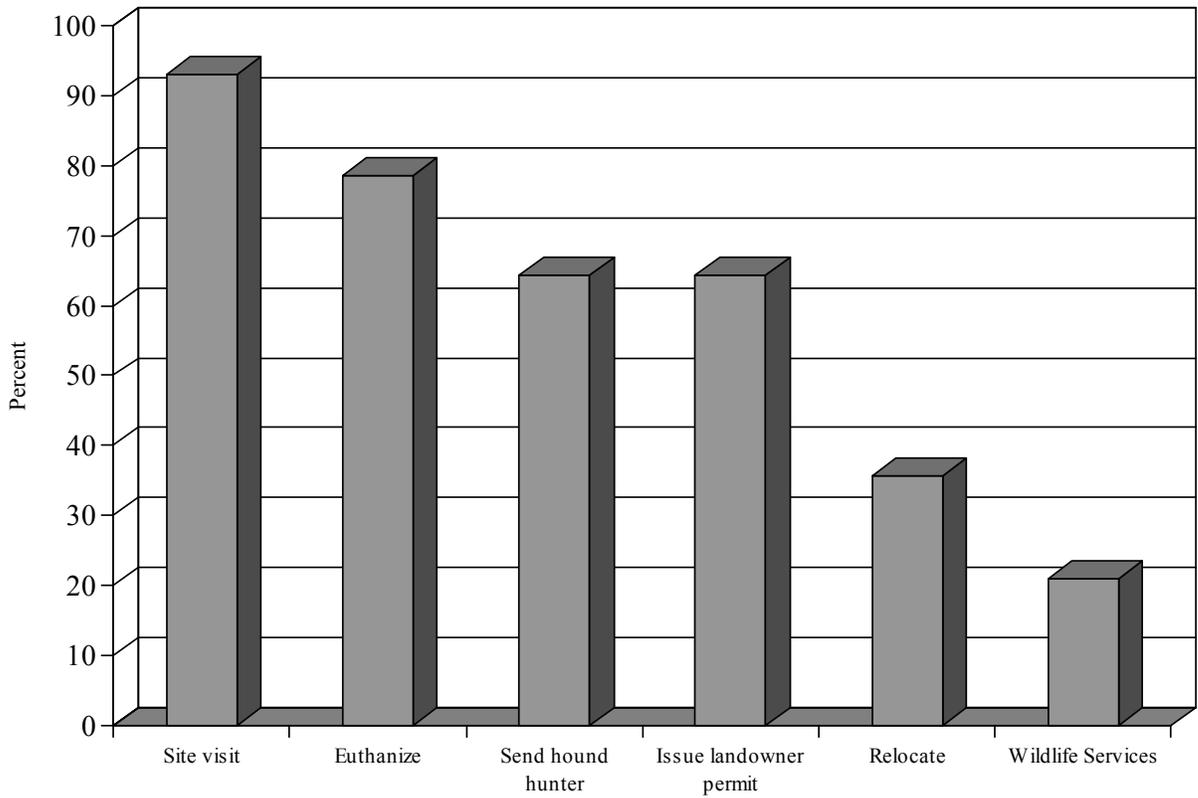
<b>Jurisdiction</b>	<b># Depredations per Year</b>	<b>Depredation Ranking</b>	<b>When Depredations Mostly Occur</b>
Alberta	30	Increasing	Winter
Arizona	50	Common	Spring
California	220	Common	N/A
Colorado	33 claims	N/A	Summer
Florida	7	Increasing	Year-round
Idaho	5	Minor	Summer
Montana	42	Common	N/A
Nevada	20	Common	Summer
New Mexico	15	Common	Spring
Oregon	302	Increasing	Variable
South Dakota	4	Uncommon	Winter
Texas	30	Minor	Unknown
Utah	N/A	Common	Winter
Washington	100	Minor	Summer
Wyoming	160	Common	Summer
Mexico	Unknown	Unknown	Summer

Twenty-four percent of agencies provided funds to reimburse owners for livestock loss caused by cougars (Alberta,[AB] CO, ID, UT, WY). In all states that provided depredation reimbursement, funds were exclusive to livestock loss (not including pet loss). Agencies without a reimbursement program indicated they were not considering developing one.

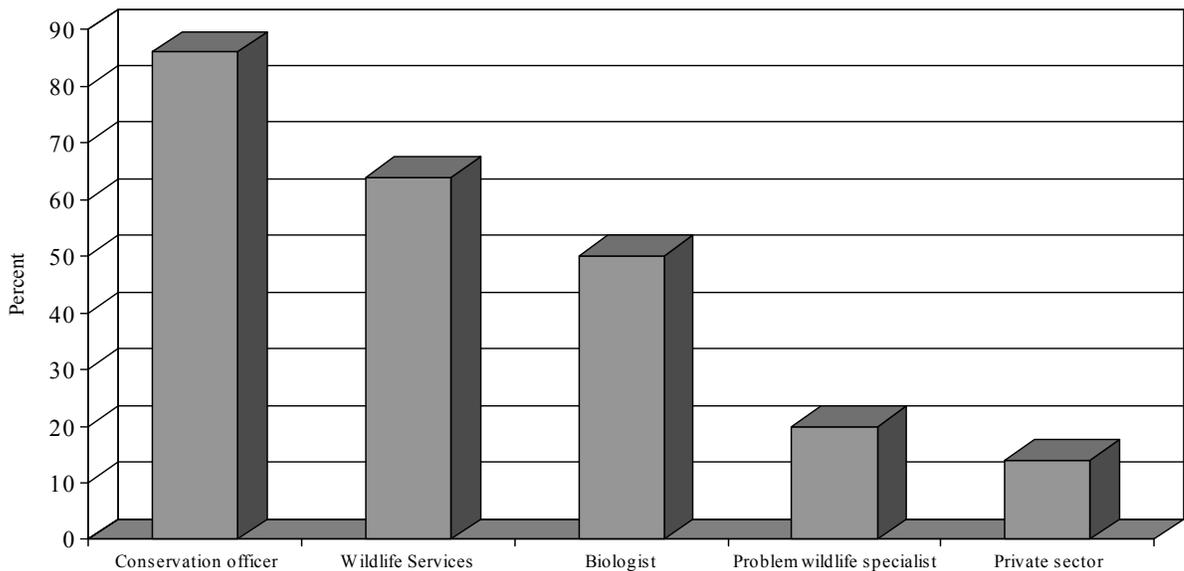


**Figure 6.** Percent of agencies who reported these as common species involved in cougar depredations, as reported in a survey of North American wildlife agencies, 2008.

When responding to depredations, agencies used various approaches, most of which resulted in the removal of the cougar involved (Fig. 7). When asked about the personnel that responded in the field, most agencies said a conservation officer (86%) followed by Wildlife Services (64%) and a biologist (50%) (Fig. 8). Forty percent of agencies indicated that the public had some influence on subsequent actions taken by their agency following a depredation (for example, the reporting party desires to kill the animal vs. relocate). However, 56% of agencies did not relocate cougars involved in depredation.



**Figure 7.** Percent of agencies whose protocols included these types of responses to cougar deprecations, as reported in a survey of North American wildlife agencies,



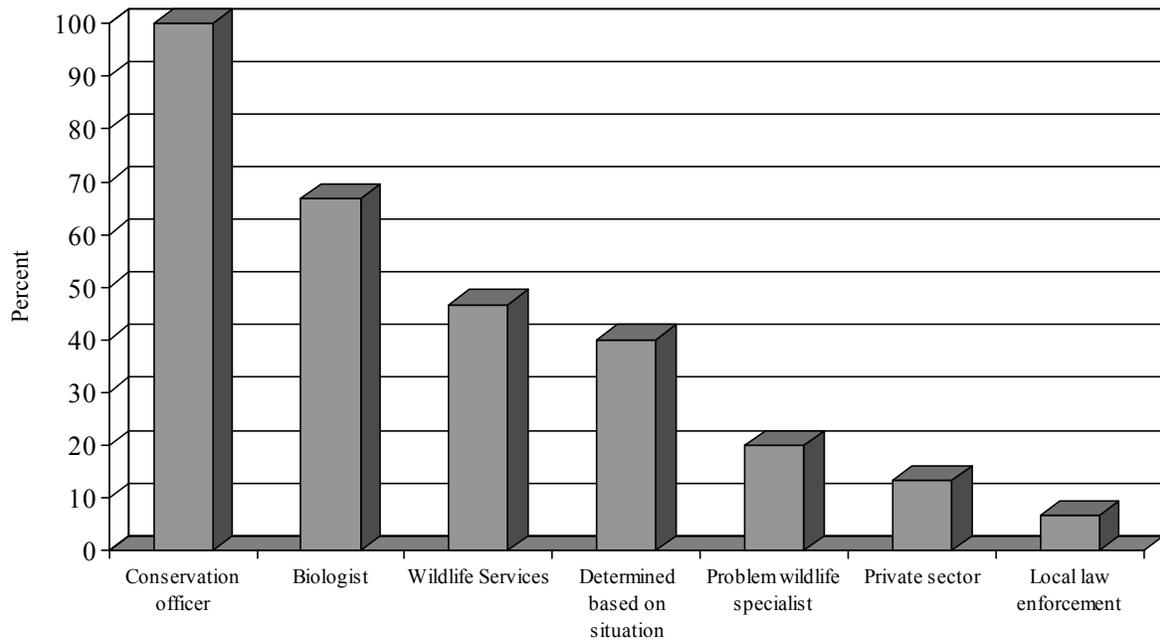
**Figure 8.** Personnel who respond to depredation situations involving cougars, as reported in a survey of North American wildlife agencies, 2008.

Ninety-three percent of agencies had a standard or defined protocol/policy that field personnel followed when responding to public safety threats involving cougars; the one agency that did not was in the process of developing one. When asked what constituted a public safety threat, all responding agencies provided a definition ranging from: any perceived human threat or conflict (UT, WA); habituation to human (AB, ID, NM, NV, WY) to an unprovoked aggressive/predatory behavior toward a human (AB, AZ, CA, CO, FL, MT, OR) (Table 8). When responding to public safety incidents, all agencies sent a conservation officer to the scene, in many cases accompanied by other personnel (Fig. 9).

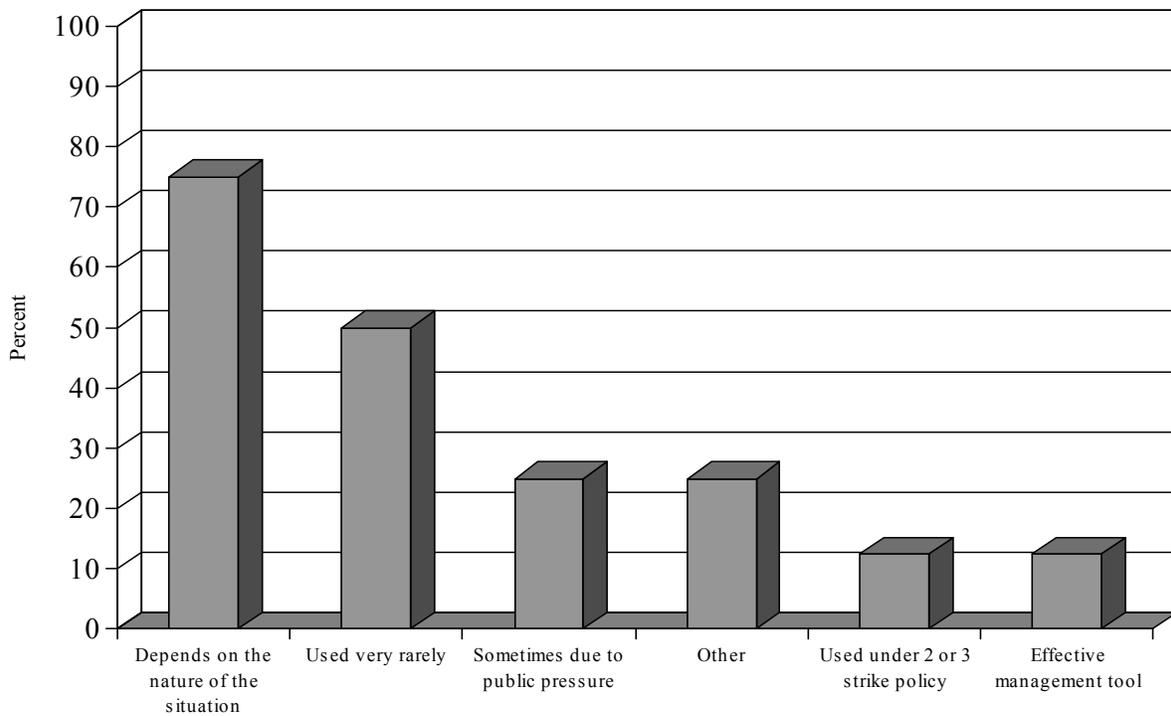
Fifty-three percent of agencies reported they may consider relocating cougars involved in public safety situations. Of the agencies that may use relocation, 75% said it depended on the nature of the situation, half said relocation was rarely used, and 25% said sometimes they relocate due to public pressure (Fig. 10). Of the factors that were considered when making this determination, apparent health of the cougar and location of

**Table 8.** Agency responses to what constitutes a public safety threat involving cougars, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

Alberta	Human/cougar interaction where the cougar is threatening or has made contact with humans. Cougar displaying habituation to human presence. Cougar staying in human-habituated areas preying on pets.
Arizona	Two categories: An incident, defined as an interaction between a human and a cougar in which the human must take an action to make the lion back down or leave the area of the human, without injury to the human. An Attack, when a human suffers bodily injury or is killed by a cougar.
California	Threat must be imminent. The totality of circumstances must indicate that there is a high probability that a person will be injured. This judgment is made by a Department employee or peace officer.
Colorado	An animal determined to be dangerous because of its behavior(s) or actions is killed. If a puma is a "public safety concern" because of its location, it could be captured and relocated - so long as it has not displayed unacceptable behaviors or actions
Florida	An unprovoked aggressive/predatory behavior toward a human that requires the individual to take defensive action to avoid direct contact.
Idaho	Habituated or food-conditioned animal, daytime activity around people.
Montana	A conflict between a human and mountain lion that may have serious results (i.e., a lion killing a dog or a lion that must be forced to back down). An on-site investigation is conducted to determine if the mountain lion is aggressive. If such a determination is made, the animal is destroyed. If the animal is determined to be a nuisance, capture and transplanting will be used to remove the animal from areas of human habitation.
New Mexico	Any cougar that continually stays in a populated area and/or preys upon domestic animals in a populated area.
Oregon	Aggressive actions directed toward a person or persons, including but not limited to charging, false charging, growling, teeth-popping, and snarling; b) Breaking into, or attempting to break into, a residence; c) Attacking a pet or domestic animal as defined in ORS 167.310; d) Loss of wariness of humans, displayed through repeated sightings of the animal during the day near a permanent structure, permanent corral, or mobile dwelling used by humans at an agricultural, timber management, ranching, or construction site.
Nevada	Any lion that confronts a person. Depredation or attack on pets. Repeatedly observed in areas where people are frequently located. In the vicinity of schools. Repeatedly in an area where a vehicle collision is possible. Any lion unyielding to humans, acting inappropriately, sick, or just repeatedly observed in an area.
South Dakota	A sick or injured lion, a lion that enters a city limit, a lion that frequents a well-populated area, aggressive behavior towards a human, attack on human.
Texas	Unprovoked behavior in relation to a human as defined by the following examples: a mountain lion displays some form of predatory behavior toward humans or pet (e.g., stalking, crouching, tail twitching, rear leg 'pumping', ears flattened, fur erected, emitting hissing or snarling sounds, rushing, attacking); a mountain lion intentionally approaches close to a human after the lion knows the human has seen it; A mountain lion that is not cornered but refuses to retreat when objects are thrown at it; a mountain lion approaches a human at close range and refuses to retreat even after the human takes evasive or aggressive action to avoid attack; a mountain lion physically attacks a human or pet. A mountain lion that has displayed aggressive behavior toward humans, including an attack on a person or pet, a mountain lion that is perceived by a trained wildlife professional to pose a serious threat to humans based on its behavior, location or other relevant circumstances.
Utah	Any threat to a person
Washington	Any perceived conflict with humans, pets, livestock or property.
Wyoming	Aggressive behavior, lion presence in urban areas, especially if habituated or around children



**Figure 9.** Personnel who respond to public safety situations involving cougars, as reported in a survey of North American wildlife agencies, 2008.



**Figure 10.** Responses to whether or not cougars were relocated in public safety situations, as reported in a survey of North American wildlife agencies, 2008.

the incident rated highest (67%). Of the agencies that relocated cougars, 58% marked the cougar before release, 17% marked it most of the time, and 25% marked the animal some of the time (Table 9). Conversely, when asked if relocated cougars were monitored after release responses were: 17% yes, 8% most of the time, 67% some of the time, and 8% never (Table 9).

**Table 9.** Agency cougar capture and relocation protocol, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Is Relocation Ever An Option?</b>	<b>Are Cougars Marked Prior to Release?</b>	<b>Do You Monitor results of cougar relocations?</b>
Alberta	Yes	Always	Some of the time
Arizona	No	Always	Some of the time
California	No	Always	Always
Colorado	Yes	Always	Some of the time
Florida	No	N/A	N/A
Idaho	Yes	Some of the time	Some of the time
Montana	Yes	Some of the time	Some of the time
Nevada	No	N/A	N/A
New Mexico	Yes	Most of the time	No
Oregon	No	N/A	N/A
South Dakota	No	N/A	N/A
Texas	No	N/A	N/A
Utah	Yes	Most of the time	Some of the time
Washington	Yes	Always	Almost always
Wyoming	Yes	Some of the time	Some of the time

In Mexico, researchers in the Jalisco, Oaxaca, and Sonora regions all reported that depredation of livestock was the most common cougar-human conflict across all jurisdictions. Pet and poultry depredation were common in the Oaxaca region, but were ranked least common in the Jalisco and Sonora regions. Across all regions, summer was the most common time of year depredations occurred. In the Oaxaca and Sonora regions, cattle was the most common species involved in depredations, but in the Jalisco region, cattle, sheep, goats, and horses all scored equally.

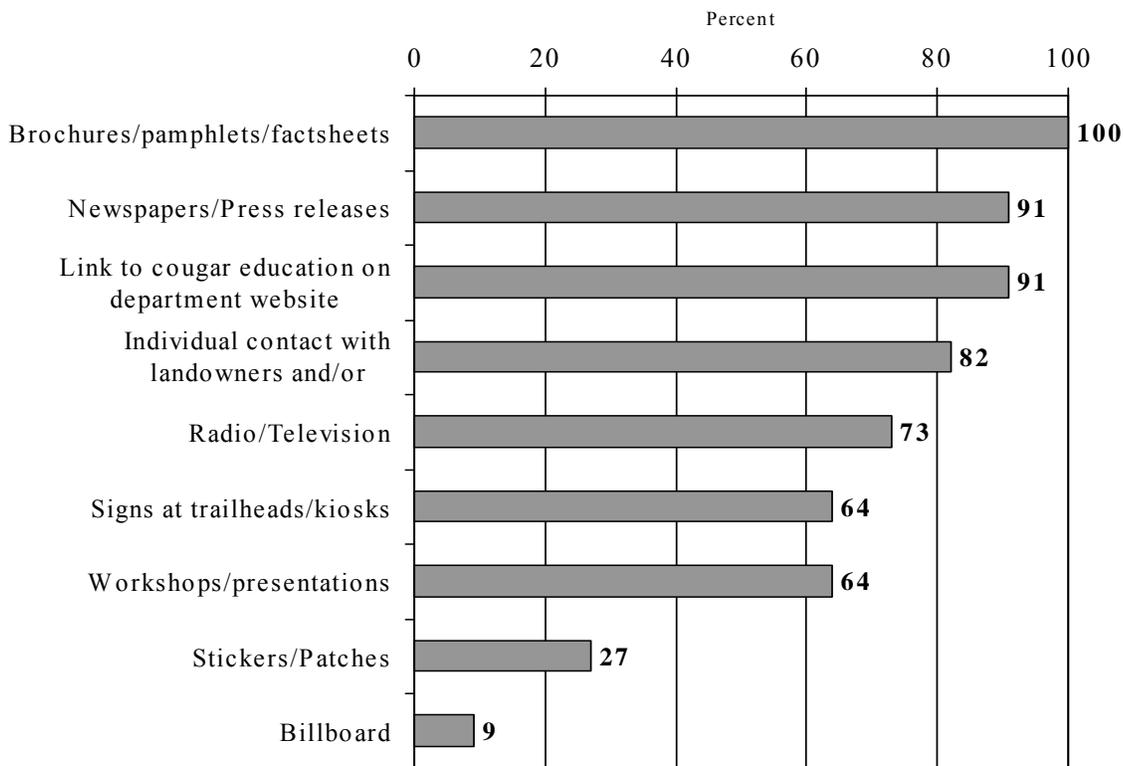
## **Education**

Seventy-three percent of wildlife agencies had a cougar education program currently in place (Table 10). When we asked personnel to rate their agency's education efforts: 13% of agencies thought they had a comprehensive approach; 40% thought their approach was adequate; and 46% rated their efforts as minimal or needing attention (Table 10). In response to the need for education in their jurisdiction, 73% of agencies said the need was increasing and 27% said the need was stable (Table 10). Agencies used a variety of ways

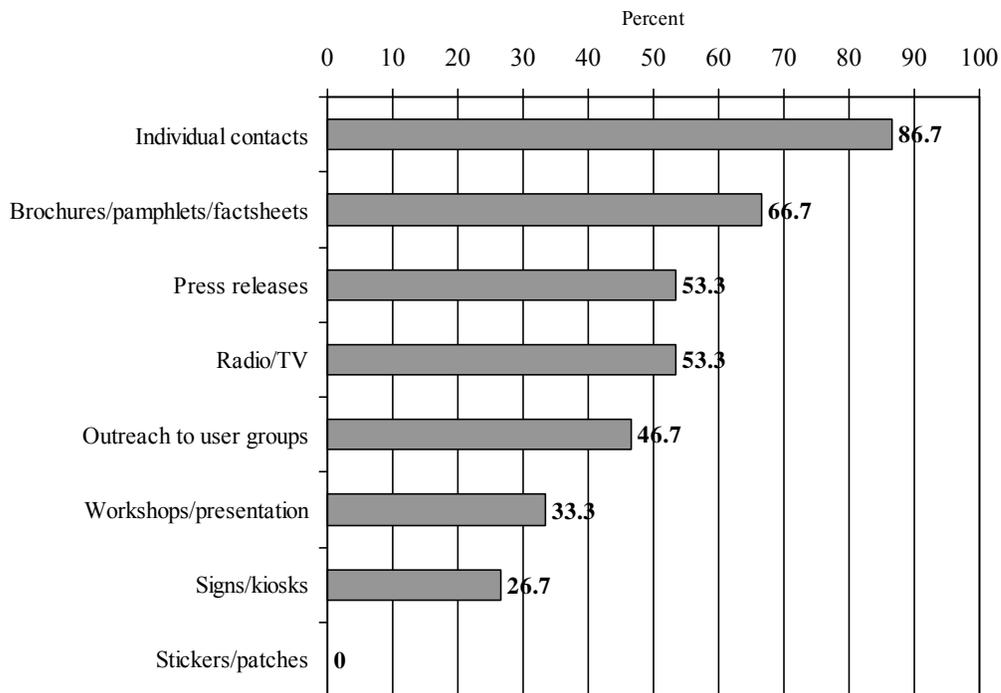
to education the public; the top 5 methods were brochures or pamphlets, newspapers or press releases, department website, individual landowner contact, and radio or television (Fig. 11). We asked agencies to rate which education materials they thought were most successful. Eighty-seven percent said contact with individual landowners was the most successful, followed by brochures/pamphlets (67%), press releases (53%) radio/television (53%), and outreach to user groups (47%) (Fig. 12). Forty percent of agencies had staff whose duties included a focus on public education and outreach regarding cougars. Of those with outreach staff, most devoted 1-5 hours per week on preventative education; 1 agency reported 8 hours per week. Sixty-seven percent of agencies conducted surveys/questionnaires to gauge their publics' knowledge or concerns regarding cougars. Of the agencies that conducted surveys, 56% had done so in the past 5 years, 11% in the last 10 years, and 44% said it had been more than 10 years (Table 11). Eighty percent of agencies worked collaboratively with Non-governmental Organizations (NGOs) (i.e., conservation and sporting groups) to help meet their public education and outreach regarding cougars. Aside from providing preventative information, we also asked agencies which approaches they would like to see used more when actually responding to cougar-human complaints in the field; education materials (79%) and outreach to user groups (79%) were the most common answers followed by outreach through TV, Radio, and newspaper (71%), aversive conditioning (29%), and the ability to fine people for creating the problem (29%) (Fig. 13).

**Table 10.** Status of cougar education programs, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

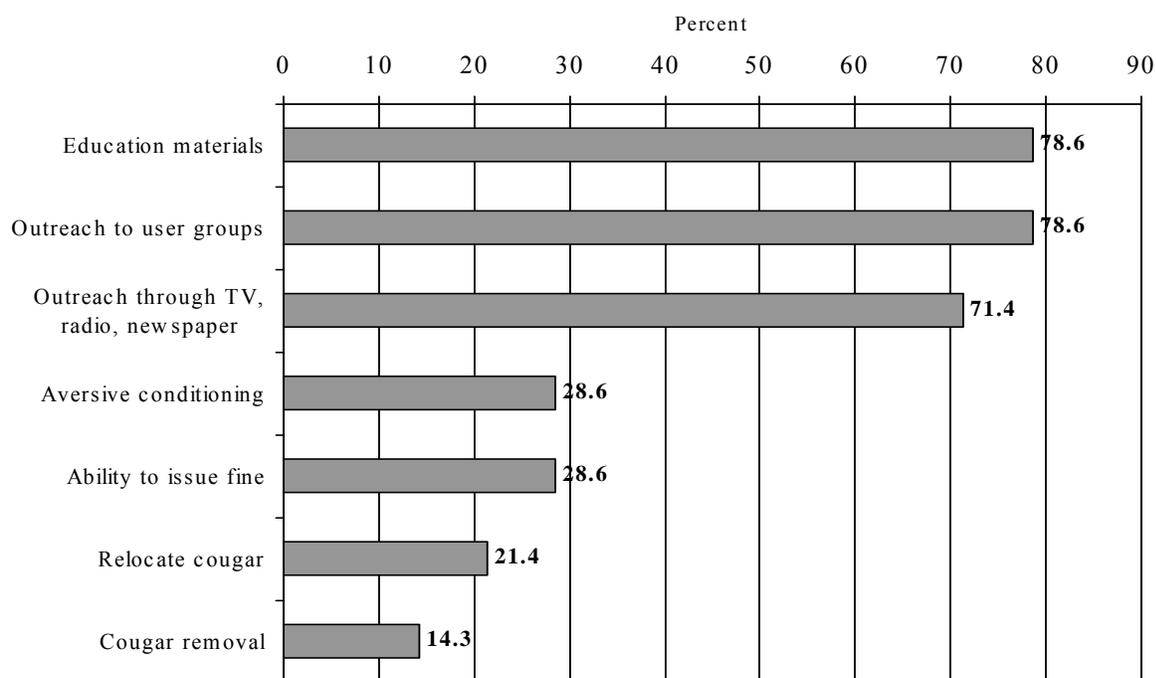
<b>Jurisdiction</b>	<b>Do You Have a Cougar Education Program?</b>	<b>How Would You Describe Your Agency's Efforts?</b>	<b>Is the Need For Education Increasing or Decreasing?</b>
Alberta	Yes	Needs attention	Increasing
Arizona	Yes	Comprehensive	Increasing
California	Yes	Adequate	Stable
Colorado	Yes	Comprehensive	Stable
Florida	Yes	Adequate	Increasing
Idaho	No	Needs attention	Increasing
Montana	No	Needs attention	Increasing
Nevada	Yes	Adequate	Increasing
New Mexico	No	Minimal	Increasing
Oregon	Yes	Needs attention	Increasing
South Dakota	Yes	Adequate	Stable
Texas	No	Minimal	Increasing
Utah	Yes	Adequate	Increasing
Washington	Yes	Needs attention	Increasing
Wyoming	Yes	Adequate	Stable



**Figure 11.** Methods agencies used to educate the public about cougars, as reported in a survey of North American wildlife agencies, 2008.



**Figure 12.** Methods of cougar education that agencies thought were most successful, as reported in a survey of North American wildlife agencies, 2008.



**Figure 13.** Which approaches that agencies use would you like to see more of when responding to cougar-human complaints, as reported in a survey of North American wildlife agencies, 2008.

**Table 11.** Agency efforts to gauge public knowledge or concern regarding cougars, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Has Your Agency Conducted Surveys to Gauge Public Knowledge or Concern Regarding Cougars?</b>	<b>When Was the Last Survey Conducted?</b>
Alberta	No	N/A
Arizona	Yes	1-5 years ago
California	Yes	6-10 years ago
Colorado	Yes	1-5 years ago
Florida	No	N/A
Idaho	No	N/A
Montana	Yes	6-10 years ago
Nevada	Yes	6-10 years ago
New Mexico	No	N/A
Oregon	No	N/A
South Dakota	Yes	1-5 years ago
Texas	Yes	6-10 years ago
Utah	Yes	No response
Washington	Yes	1-5 years ago
Wyoming	Yes	1-5 years ago

In terms of education and outreach involving sport hunters, 27% of responding agencies offered some type of education to help hunters distinguish gender or age of cougars; 2 agencies (13%) had mandatory programs (CO and WA) (Table 12). Of the 74% that did not have a program, 67% said they were not considering implementing one at this time (Table 12).

In Mexico, all researchers worked closely with local communities to provide education on conflict prevention within their project areas. However, because there was no agency support for an education program, education was limited across the jurisdiction.

**Table 12.** Agency efforts to educate cougar hunters, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Do You Have an Education Program to Help Hunters distinguish Gender or Age of Cougar?</b>	<b>If No, Is Your Agency Considering One?</b>	<b>If Yes, How is it offered?</b>
Alberta	No	Not at this time	N/A
Arizona	No	Not at this time	N/A
California	No	Hunting is illegal	N/A
Colorado	Yes	N/A	Mandatory, online or written
Florida	No	Hunting is illegal	N/A
Idaho	No	No longer available	N/A
Montana	No	Yes	N/A
Nevada	No	Not at this time	N/A
New Mexico	No	Not at this time	N/A
Oregon	No	Not at this time	N/A
South Dakota	No	Yes	N/A
Texas	No	Not at this time	N/A
Utah	Yes	N/A	Brochures provided with license Mandatory, brochures provided with license
Washington	Yes	N/A	
Wyoming	Yes	N/A	Voluntary, online or written

## **Discussion and Management Implications**

### **Cougar Management Plans**

Results of this survey brought to light the challenges and complexities inherent in managing cougars. We found that agencies put a considerable amount of effort and resources into addressing biological, social, and political concerns and incorporating input from outside sources and user groups. The differences among management plans were seen primarily in the amount of time in which plans were updated. Sixty three percent of the responding agencies said their plans were updated every 7-9 or 10+ years. In general, most agency management plans served more as a guide than a rigorously adhered document. In some cases, management plans may be used to structure sport-hunting seasons, incorporate quotas, and adjust quotas to reach harvest goals. With this type of flexibility (specific to harvest), updating management plans every 1-3 years may not be necessary. However, all agencies said that research, harvest statistics, peer-

reviewed scientific information, and public influence were used in development of management plans. Considering these points, it could be argued that updating management plans every 7-10 years or more may not effectively incorporate these dynamic factors. In fact, 2 common criticisms agencies received regarding management plans were that inadequate science was being used and public opinion was not being addressed (Table 13). It should also be noted that, in some cases, legislation could force social and political influence into the biological arena of cougar management; in Washington, 16 legislative bills regarding cougar management have been introduced since 1996 (Washington State Legislature, 2008). Overall, resolving these limitations will likely take various approaches. For using science to develop in management plan, we recommend agencies conduct field research in their jurisdictions. Despite the obvious financial commitments, well-designed field research provides the best method for evaluating cougar population. For assessing public opinion, agencies may want to refine their survey protocols. Typically, agencies survey their public at periodic meetings with a limited audience; a more balanced and representative approach may be to use a random-sampling technique to assess public opinion. This would allow agencies to understand public perceptions jurisdiction-wide and also gather information to create effective outreach methodologies.

**Table 13.** Public comments and criticisms commonly received by agencies regarding cougar management plans, by jurisdiction, as reported in a survey of North American wildlife agencies, 2008.

<b>Jurisdiction</b>	<b>Comments /Criticism Commonly Received Regarding the Cougar Management Plan</b>
Alberta	The plan needs updating with information from current research and knowledge.
Arizona	<i>No response provided.</i> No Management Plan
California	Sportsmen want to hunt lions in CA, and law prohibits that. The public wants problem lions moved, but our policy generally prohibits translocation.
Colorado	We have 19 discrete Data Analysis Unit plans. Some interests complained that it meant commenting on each and trying to get their staff to each meeting in many different parts of the State. Other interests feel our biological parameters were too restrictive. We made them that way in order to operate under conservative or moderate assumptions given lack of information on the species. But generally, both interests accept the plans.
Florida	N/A, No Management Plan
Idaho	That the management plan relies on age structure without knowing what the data really mean.
Montana	N/A, No Management Plan
Nevada	We hunt too much or not enough. (see-saw aspect of anti-hunting vs. pro sportsmen groups). We get criticism for not harvesting more lions.
New Mexico	We don't have enough research into the actual population estimates of cougars and we rely upon estimates to make management decisions
Oregon	General opposition to the plan, inadequate science, insufficient data for decision-making, dislike for active management, desire for more preservation/conservation, desire for more aggressive management, general support for the plan.
South Dakota	We constantly receive comments that our plan does not produce "raw data" collected from ongoing research and surveys conducted by the Department.
Texas	N/A, No Management Plan
Utah	Too liberal, too conservative
Washington	Not enough science being used. Frustration with legislation. Input into plans was limited.
Wyoming	<i>No response provided</i>

## **Population Status**

A vital prerequisite for managing most wildlife species is a credibly accurate assessment of population size (Caughley and Sinclair 1994). As biologists, we understand the predicament agencies are faced with when estimating cougar populations; this species is among the most demanding to study. It is recognized that a reliable and accurate method for enumerating cougar populations is lacking (Lindzey 1987, Ross et al. 1996). Nonetheless, population estimation is the foundation used to create management-guiding documents and formulate scientifically credible decisions. Agencies with insufficient data may continually be criticized. Our survey revealed that although most agencies were using more than one source of information for deriving population estimates, evaluation of hunting harvest data was the most commonly used method. While harvest data is a constant and useful source of information, it should be evaluated with scrutiny because it is not reflective of population status (Anderson and Lindzey 2005) and snowfall may influence harvest significantly. Only half the agencies were incorporating field research or GIS analysis in developing population estimates; many agencies relied on modeling, using densities reported in the literature multiplied by the amount of available habitat. Because population estimates are a parameter that influences all aspects of cougar management protocols, agencies may want to scientifically evaluate their own cougar management programs and address population estimation in a more scientifically-defensible manner.

## **Cougar database management**

Almost all agencies had a mandatory reporting system for recording cougar mortalities (except TX and Mexico [MX]), and agencies collected a considerable amount of data from kills for their databases (Table 10). While the data collected was important, agencies may want to collect some additional biologically important data while the carcass is readily available. For instance, while most agencies collected a tooth to age cougar kills using cementum annuli, less than 1/3 of agencies collected measurements on gum-line recession. It has been reported that aging cougars based solely on cementum annuli may not be precise (Trainer and Mattson 1988). Since many agencies rely on population reconstruction using harvest data, agencies may want to use multiple aging techniques for accurate modeling (Anderson and Lindzey 2005). Collecting gum-line recession measurement has showed promise in being more accurate for aging live cougar (Laundré et al. 2000) but some standardization for measuring is necessary when numerous personnel are involved and training may be needed to enhance consistency and accuracy. Also, little is known how the gum-line recesses after death (Laundré et al. 2000) and agencies could add knowledge to this science by collecting this data. Agencies may also want to consider collecting the lactation status on female mortalities; this data could be valuable for population modeling and recording kitten mortality (Ruth et al. 2003). It may also help accurately age cougars that get classified as 2-3 year-old cougars with an error rate of  $\pm 1$  year using cementum annuli (Anderson and Lindzey 2005).

Most agencies collected useful and pertinent data on cougar depredations (date, location, species attacked, data on cougar if dispatched). However, only half the agencies collected data on contributing factors that may have led to the depredation.

Understandably, identifying the factors that may contribute to a depredation is a science in itself and field personnel seldom receive training on kill-site investigation or in subsequent media response when present. This may explain why almost 2/3 of agencies employ the help of Wildlife Services and hunters from the private sector to respond to depredation situations. While this may be an effective means of removal, it may not always remove the animal that depredated, may not identify the contributing factors, and ultimately may not result in a solution to avoid a recurring problem. Agencies may want to consider training programs for in-house specialists to provide the response, suggestions for avoidance, and work to educate members of the public affected by depredation. This would help to insure that a consistent message is delivered to affected landowners, may improve accurate agency record keeping, and may result in a more effective partnership with the public.

### **Cougar-Human Conflict**

The identification of species commonly depredated across all jurisdictions can be used to help agencies narrow education efforts to reduce livestock depredation and associated conflict. For example, both northwest and southwest agencies identified sheep and goats as the top 2 livestock species depredated and the majority of agencies reported that spring was the season when most depredations occurred. Therefore, agencies may want to focus education efforts on sheep and goat producers and do so in winter when producers are preparing for reproduction. Similarly, pet depredation was common across all jurisdictions and occurred overwhelmingly during winter and agencies may want to focus education efforts focused in fall when it would be most beneficial (similar to addressing bear conflict education in spring when bears emerge from dens).

Capture and relocation of cougars involved in public safety incidents (other than depredations) was not a common management technique and agencies reported they utilized the technique sparingly. The overwhelming majority of agencies did not feel relocation was an effective management technique (only 1 agency said it was effective). Overall, it was unclear to us the criteria agencies were using to make the determination that relocation was not effective. When relocation was performed, only 7 agencies always marked individuals and only 2 always monitored relocated cougars. In addition, the definitions agencies used to describe what constituted a public safety situation (thus removal of individuals) ranged from a perceived threat to a human attack. It appeared that public input in some jurisdictions was resulting in more use of relocation, and in others there was outright public demand to explore relocation instead of lethal removal. For example, in California, where law prohibits hunting, much of the public would like to see translocation used more, but policy generally prohibits translocation. Relocating cougars into occupied range may result in intraspecific strife so we recommend more work be conducted by agencies to test the hypothesis that local relocation (within that animal's average home range) may be an effective management technique. It may also be beneficial for agencies to examine their public safety definitions and work with other

agencies towards a standardized language so more latitude is given to relocate cougars that may meet agency criteria for relocation (Ruth et al. 1998).

## **Education**

Education and outreach components often receive limited attention in proportion to other cougar management needs. This general observation was reflected in our survey where only 13% of agencies described their education efforts as ‘comprehensive’ and only 40% allocated staff time to the needs of cougar education. Despite this, 73% of agencies stated that the need for education was increasing, which suggests that an important element of successful cougar education is being overlooked across the majority of this species’ range. An agency effort to gauge public knowledge or concern regarding cougars was also minimal. In fact, only 33% said they had surveyed their public in the past 5 years. Most agencies employ education strategies that included brochures, web content, press releases, and some workshops but the most desired approach was increased direct contact. Eighty-seven percent of agencies said that individual landowner contacts were the most effective means of relevant information dissemination. This type of outreach is often the most labor-intensive and efforts may be stifled due to funding limitations. If agencies feel the benefits outweigh the costs, it seems appropriate that agencies consider periodically educating from within. In many agencies, there is a disconnect between wildlife and enforcement programs that can be easily overlooked. Providing field personnel with training on cougar response will ensure a clear and consistent message when responding to such incidents. In order to fully gauge the efficacy of public outreach, agencies may want to survey public opinion and knowledge on a regular basis. Two-thirds of the agencies had conducted surveys in the past but most did not do so with any regularity. Surveys can be costly, but the long-term gains in identifying knowledge gaps and opinions on ways to deliver the most critical information about cougars to the public can often mitigate later, more reactive management techniques such as lethal removal or aversive conditioning and relocation. We found 2 examples of some inventive ways to address cougar education that we think would be useful for agencies to explore. First, in Colorado, work is being conducted to establish regulations for realtors that would require that cougar awareness become part of disclosure in purchases (Jerry Apker, personal communication). This would be an important first step in addressing preventative education for residents that may not be aware that predators inhabit the area. Too often, realtors sell the mountain views, rolling hills, rivers, and meadows, without disclosing predator occupation. Second, California’s agency is utilizing billboards to convey messages regarding cougar education, reaching virtually tens of thousands of people every day. While this seems like a common-sense approach, we found no other agency using billboards and we recommend expansion of this innovative idea.

In the comment section of our survey, many agencies felt much of the education materials given to landowners were not effectively being implemented and problems with conflict were recurring, warranting the use of fines. For agencies that may pursue the use of fines, a database to track and monitor their effectiveness (to determine if conflict subsides as a result of issuing fines) would be beneficial. This information could be

valuable for generating agency support, furthering education, and ultimately improving cougar management.

Two agencies had mandatory hunter education programs (CO and WA) and 2 had voluntary programs (UT and WY) that assisted hunters in identifying cougars of different sex and age classes. Where hunting with hounds is permitted, sexing and aging cougars in a tree takes experience, and it becomes increasingly difficult in other hunting situations. The importance of being able to sex cougars before they are shot may be an important harvest strategy and can reduce kitten mortality. Regardless of the structure of hunting seasons, agencies may want to consider improving their efforts to educate hunters on identifying sex and age of cougars and how hunters can help agencies meet management objectives.

## **Conclusion**

Comparative surveys such as this one are useful for agencies to (1) evaluate cougar management across jurisdictions, and (2) work to advance management protocols throughout the species' range. However, this survey was by no means exhaustive. It would be useful if follow-up surveys were done periodically to keep information current and readily available. In addition, we encourage others to investigate further into these and other topics to provide a better understanding of specific issues that affect cougar management. Finally, we suggest that agencies use surveys to review management protocols of other jurisdictions in an effort to encourage a more collaborative approach to cougar management across jurisdictional boundaries.

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Appendix A.

2008 COUGAR MANAGEMENT SURVEY

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Contact Information

Name:

Name of Agency:

Phone number:

E-mail:

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**Management Plans**

- 1) Does your state/province have a cougar management plan?
- Yes
  - No (if no proceed to next section, starting with question 13)
- 2) Is your cougar management plan a stand-alone document or part of a larger "game management plan"?
- It stands alone
  - It is part of a larger "game management plan "
- 3) What are the sources of information used in creating your cougar management plan? (Please check all that apply)
- Input from biologists within the agency
    - Input from other wildlife professionals
    - Research conducted with in the state
  - Research conducted in other states
    - In-state cougar statistics (harvest data, depredation data, conflict data)
    - In-state ungulate statistics (harvest data, depredation data, conflict data)
    - Peer reviewed scientific publications
    - Non-peer reviewed scientific information
    - Other. Please explain
- 4) Who actually writes the cougar management plan in your state?
- Biologist(s)
  - Manager(s)
  - Other agency personnel
  - Other. Please explain
- 5) When developing your cougar management plan, who provides input? (Please check all that apply)
- Agency personnel
    - Sporting public
    - General public
    - Other in-state agencies
  - Non-governmental organizations
    - Biologists from other agencies
    - Other wildlife professionals
    - Other. Please explain

6) How does your agency solicit non-agency input when developing the management plan?  
(Please check all that apply)

- Public meetings
- Upon request we provide a draft
- It is available online
- We do not solicit non-agency input
- Other. Please explain

7) Who is the intended audience of your cougar management plan? (Please check all that apply)

- Primarily agency individuals
- Primarily other wildlife professionals
- The general public
- Other. Please explain

8) How often is your cougar management plan updated?

- Every 1-3 years
- Every 4-6 years
- Every 7-9 years
- It's been 10 or more years

9) What influences change to your cougar management plan? (Please check all that apply)

- Updated scientific information
- Changes in harvest structure
- Changes in ungulate populations
- Social factors/Public influence
- Political factors/Legislation
- Non-governmental organization input
- Other. Please explain

10) How is your management plan made available to the public after completion?  
(Please check all that apply)

- We mail a copy upon request
- We e-mail a copy upon request
- Copies are available at agency offices
- It is online and available to download

11) Managing cougar can be difficult when biological, social, and political factors are continually changing. Therefore, an established management plan may not provide the flexibility to guide all management decisions. Given these complexities, please describe how your agency utilizes your cougar management plan for "on the ground" decision-making?

12) What comments and/or criticisms (if any) do you receive regarding your cougar management plan?

(Optional) Please share any other thoughts regarding cougar management plans in your state/province.

### Population Estimates

13) Given your agency's current management needs, do you think acquiring cougar population estimates are a priority?

- Yes
- No

14) Do you have a cougar population estimate/range (even a rough one) for your state/province?

- Yes If yes, what is the estimate/range?
- No

15) What methods/information is used to derive cougar population estimates in your state/province? (Please check all that apply)

- Evaluation and/or extrapolation of hunter harvest information
- Track transects
- Field research (i.e. mark-capture or DNA studies)
- Habitat assessment (i.e. GIS analysis)
  - Extrapolation using densities with similar habitats reported in the literature
- Other (explain)
- No estimates are made

16) What areas of your state/province are used in developing cougar population estimates? (Please check all that apply)

- Statewide (throughout suitable cougar habitat)
- Regionally and then extrapolated statewide
- In hunting areas
- In non-hunting areas
- other (explain)

17) How often are cougar population estimates updated?

- every 1-3 years
- every 4-6 years
- every-7-10 years
- more than 10 years
- other (explain)

18) How do cougar population estimates influence management in your state/province? (Please check all that apply)

- Population estimates are used for informational purposes
- Population estimates are used to refine cougar management plan
- Population estimates are used to adjust sport harvest levels/quotas
  - Population estimates may be used to evaluate management decisions regarding ungulate populations
- other (explain)

(Optional) Please share any other thoughts regarding cougar population estimates in your state/province.

---

### Database Information

19) What information is collected for your state cougar database? (Please select all that apply)

**19a) Hunting information**

- Number of total kills annually
- Number of cougar tags sold
- Numbers hunters in the field
- Hunter effort (i.e. # days each hunter spent hunting)
- Gender information of kills
- Date of Kill
- Age (or age class) of kills
  - tooth collection
  - cementum analysis
  - gum recession
    - Body condition of kills
- Location of harvest
  - per hunt unit
  - per region
    - Weapon type (i.e. archery, muzzleloader, modern firearm)
    - Kill type (i.e. roadkill, hunt kill, landowner permit, poached)
    - Other (explain)

**19b Depredation Information**

- Number of depredations occurring each year
- Location of depredation
  - Date of depredation
- Gender information (if cougar is dispatched)
- Age assessment or age class (if cougar is dispatched)
  - Possible contributing factors of depredation (i.e. feeding wildlife, husbandry practices, free-ranging livestock, etc)
  - Species of animal attacked or killed
  - Other (explain)

**19c Sightings**

- Sightings are not investigated
  - Sightings are documented but not investigated
- Location of sighting
  - Date of sighting
- Other (explain)

(Optional) Please share any other thoughts regarding cougar database management in your state/province.

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**Cougar-Human Conflict**

20) Please rank the following cougar-human interactions in order of occurrence?  
(Please number 1=most common to 6=least common)?

- General cougar sightings
- Cougar prey kill reports
- Cougar/ Human encounters
- Depredation of livestock
- Depredation of domestic pets
- Depredation of poultry (chickens, ducks, etc)

21) Which cougar-human conflicts are investigated in the field by agency personnel? (Please check all that apply)

- General cougar sightings
- Wild prey-kill reports
- Cougar/ human encounters
- Depredation of livestock
- Depredation of domestic pets

22) Over the past 5-10 years, how would you rank each of these cougar-human interactions? (0=no problem, 1=minor problem, 2=common problem, 3=increasingly common problem, 4=serious problem. Numbers can be use more than once)

- General cougar sightings
- Wild prey-kill reports
- Cougar/ Human encounters
- Depredation of livestock
- Depredation of domestic pets

23) Is there a particular time of year in which these interactions are most common? (Please check all seasons that apply)

(1=Spring (March-May), 2=Summer (June-August), 3=Fall (September-November), 4=Winter (December-February), 5=year-round)

- General cougar sightings
- Deer-kill reports
- Cougar/ Human encounters
- Depredation of livestock
- Depredation of domestic pets

What is the average number of depredations involving cougar in the past 5 years?

24) Of the confirmed depredation complaints involving cougars, which is the most common? Please number 1-6 (1=most common, 6=least common)

- Domestic Pets (dogs and cats)
- Livestock (cattle)
- Livestock (sheep)
- Livestock (goats)
- Livestock (horses)
- Livestock (poultry)

25) Does your Agency have a standard or defined protocol or policy that field personnel follow when responding to depredation events involving cougars?

- No
- Yes

If yes what does your protocol include (please select all that apply)

- Have agency personnel visit the site to evaluate depredations, course of action, and offer suggestions to avoid future conflicts
- Capture and relocate the cougar
- Capture and/or kill the cougar
- Send hunters and/or hound handlers to kill/chase the animal
- Issue a landowner kill permit to remove the cougar if it returns
- Other (explain)

26) What type of agency personnel usually responds in the field to cougar depredation complaints?

- Biologist

- Game Warden/Conservation Officer
- Problem/Nuisance Wildlife Specialist
- Wildlife Services
- Private Contractor
- Other (explain)

27) Does your agency currently have a damage fund to reimburse owners for livestock loss caused by cougars?

- No.
  - If No (please select all that apply)
    - Not at this time
    - Not at this time but did have such a fund in the past
    - Not at this time but the department is considering one
- Yes
  - If Yes, (please select all that apply)
    - Damage funds are paid for livestock losses only (excludes domestic pets)
    - Damage funds are paid for domestic pets only (excludes livestock)
    - Damage funds are paid for livestock and/or domestic pet losses
    - Other (explain)

28) In depredation situations, do the desires of the reporting party have any influence or impact on subsequent actions taken by your agency? (For example, the reporting party desires to kill the animal vs. relocate it)

- No. All subsequent actions are determined by agency personal (or designated responding party)
- Yes
  - If Yes, (please select all that apply)
    - Yes, when the decision is to dispatch the animal or not
    - Yes, when the decision is to relocate the animal or not
    - Yes, when the decision is to relocate or dispatch the animal

(Optional) Please share any other thoughts regarding cougar–human conflict in your state/province.

**Public Safety**

29) Does your Agency have a standard or defined protocol/policy that field personnel follow when responding to public safety threats involving cougars?

- No
  - If No (please select all that apply)
    - Not at this time
    - Not at this time but the department is considering developing one
    - Not at this time but the department is in the process of developing one
- Yes
  - If Yes (please select all that apply)
    - Have agency personnel visit the site to determine the cause, course of action, and offer suggestions to avoid future interactions
    - Capture and relocate the cougar
    - Capture and kill the cougar
    - Send hunters and/or hound handlers to kill/chase the animal
    - Issue a landowner kill permit to remove the cougar if it returns
- Other (explain)

30) What type of agency personnel responds in the field to public safety threats involving cougars? (Please check all that apply)

- Biologist
- Game Warden/Conservation Officer
- Problem/Nuisance Wildlife Specialist
- Wildlife Services
- Private Contractor
- Responding party is determined by situation (i.e. location of depredation, availability of department personal etc.)
- Other (explain)

31) Who decides the course of action to be taken in public safety threats involving cougars? (Please check all that apply)

- Biologist
- Regional Supervisor
- Game Warden/Conservation Officer
- Wildlife Services
- Private contractor
- Responding party
- Other (explain)

32) In your state/province, please define what constitutes a public safety threat involving cougars?

(Optional) Please share any other thoughts regarding public safety in your state/province.

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### Capture and Relocation

33) Is capture and relocation an option for cougars involved in conflict (depredation, public safety)? (Please select all that apply)

No. It is never used (Proceed to question 38).

Yes.

If Yes, (please select all that apply)

It is an option but is used very rarely

The decision to use it depends on the nature of the problem (depredation vs. public safety)

It is sometimes used in response to public pressure in favor of it

It is more often used in response to public pressure in favor of it

It is considered an effective management tool

It is used as part of a 2 or 3 strike policy

Other (explain)

34) If capture and relocation is an option for cougars involved in depredation events, what factors are considered? (Please select all that apply)

Estimated age of the animal

Apparent health of the animal

Desires of the person reporting the depredation complaint

Previous number of depredations associated with this individual

The location of the depredation complaint

Possible contributing factors of depredation (i.e. feeding wildlife, husbandry practices, free-ranging livestock, etc)

- Cougars are not relocated when involved in a depredation
- Other (explain)

35) If capture and relocation is considered for cougars involved in public safety events, what factors are considered in making this assessment? (Please select all that apply)

- Estimated age of the animal
- Apparent health of the animal
- The number of sightings of the animal
- The location of the animal (ex. park vs. near housing development)
  - Desires of the person/s making the public safety complaint
- Cougars are not relocated when involved in a public safety incident
  - Other (explain)

36) Are relocated cougars marked prior to release?

- Never
- Some of the time
- Most of the time
- All the time

37) Does your agency attempt to monitor results of cougar relocations?

- No
- Sometimes
- Almost always
- Always
- Other (explain)

(Optional) Please share any other thoughts regarding capture and relocation of cougars in your state/province.

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### Education

38) Does your agency have a "cougar aware" or cougar education program?

- No

- Yes

If yes, what education materials does your agency provide and use?

- Brochures / pamphlets/fact sheets
- Stickers /patches
- Signs at trailheads/kiosks
- Newspapers/Press releases
- Radio / Television
- Workshops/ presentations
- Individual contact with landowners and / or recreationists
- Link to cougar education on department website
- Other

39) How would you describe your agency's cougar education efforts?

- Comprehensive
- Adequate
- Needing attention
- Minimal
- Other. Please explain

40) Does your agency have staff whose role includes a significant focus on public education and outreach regarding cougars?

- Yes
- No

If yes, approximately how many total staff hours per week are devoted exclusively to public education and outreach regarding cougars?

41) Does your agency work with NGO's (i.e. conservation, sporting groups) to help meet your public education and outreach regarding cougars?

- Yes
- No

42) Has your agency conducted surveys/questionnaires to gauge the publics' knowledge or concerns regarding cougars?

- No. It has not been done in the past
- No. It has not been done in the past, but our department is considering it

- Yes

If yes (please select all of the following that apply)

- It has been conducted in the last 5 years
- It has been conducted in the last 10 years
- It has been conducted more than 10 years ago
- It has been conducted on the general public
- It has been conducted during a department-sponsored presentation on

cougars

- It has been conducted primarily on sportsman
- It has been conducted on the general/sporting public combined
- It has been conducted on statewide (or nearly statewide)
- It has been conducted only in specific regions of the state
- Results of the survey have had some influence on management decisions
- Results of the survey are used primarily for information purposes
- Other (explain)

43) Within your state, do you feel the need is for public education regarding cougars is:

- Increasing
- Decreasing
- Stable

44) Does your agency offer or require any specific cougar training or education program for sport hunters (i.e. to help hunters distinguish gender or age of animal)

- No

If No, (please check all that apply)

- We are considering developing a mandatory program
- We are considering developing a voluntary program
- We are not considering establishing such a program at this time
- We previously offered this type of program but it is no longer available

- Yes

If yes, (please check all that apply)

- We have a program in place but it is voluntary
- We have a program in place and it is mandatory
- The program is available on-line
- The program is offered in a classroom setting
- The program is offered through written material

Other (explain)

45) What approaches would you like to see your agency use more of when trying to educate the public on prevention of cougar-human interactions?

- Brochures/Pamphlets/Fact Sheets
- Stickers/patches
- Signs at trailheads/kiosks
- Press releases
- Radio / Television
- Workshops/Presentations
- Other (explain)

46) What approaches would you like to see your agency use more when responding to cougar-human interactions?

- Educational materials
- Relocate cougars and monitor success
- Aversive conditioning (i.e. dogs)
- Legislation or fines for attracting wildlife
- Cougar removal
- Outreach to media (TV, radio, newspapers)
- Outreach to user groups (developments, schools, livestock groups, farmers, recreation groups, etc)
- Other (explain)

47) What approaches do you feel have been most successful in reaching the public to share educational information regarding cougars and cougar interactions?

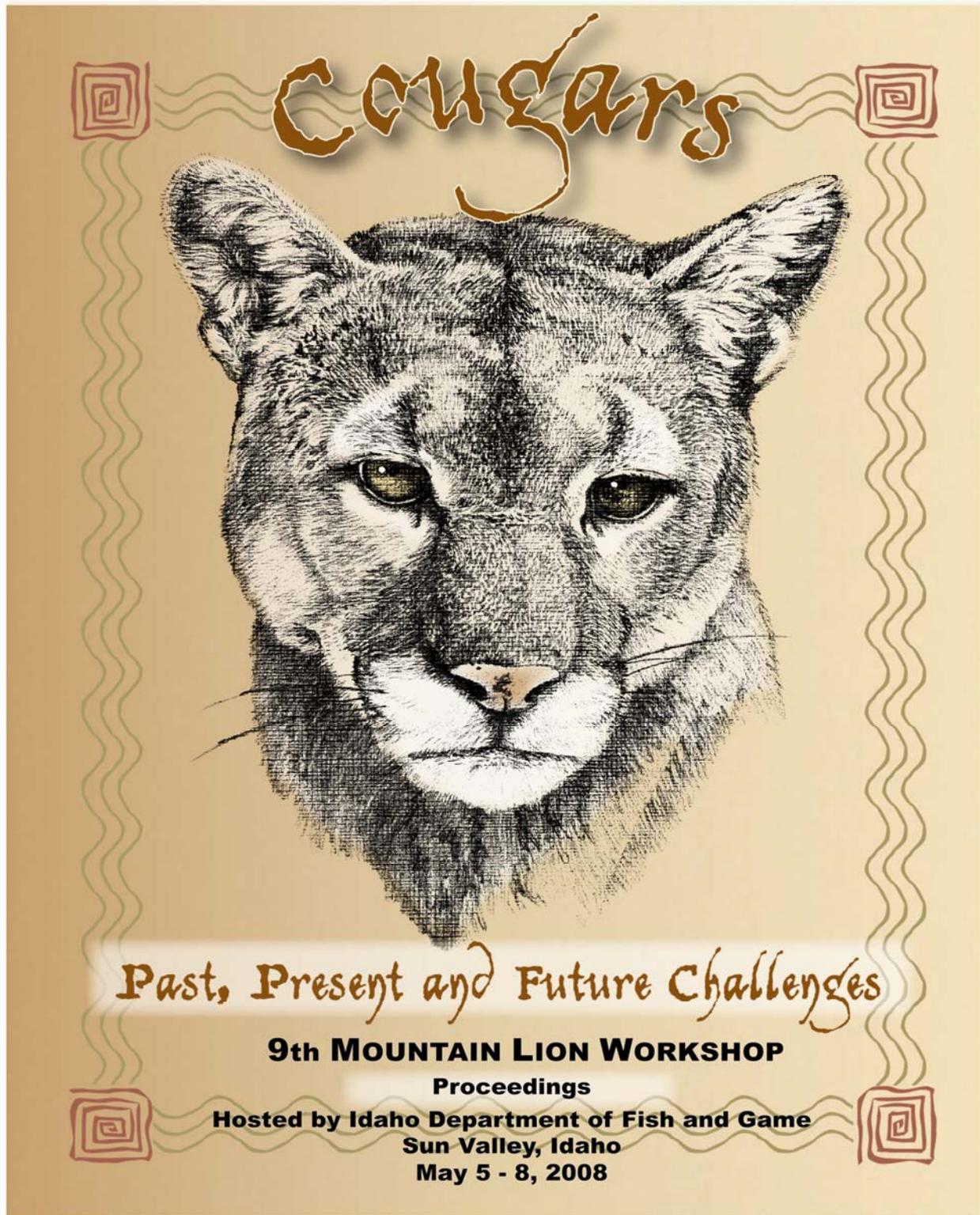
- Brochures/Pamphlets / Fact Sheets
- Stickers/patches
- Signs at trailheads/kiosks
- Press releases
- Radio / Television
- Workshops / Presentations
- Outreach to user groups (developments, schools, livestock groups, farmers, recreation groups, etc)
- Individual contact with landowners and / or recreationists
- Other (explain)

(Optional) Please share any other thoughts regarding public education of cougars (or the need for) in your state

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# Poster Session



## Ecology of a Re-established Cougar Population in Southeastern Alberta and Southwestern Saskatchewan

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**ABSTRACT** Cougars (*Puma concolor*) were distributed throughout Alberta historically, but in the early 1900s, likely due to predator control and agricultural expansion, became limited to the southwest region of the province. Not until the late 1990s had cougars begun re-populating their eastern Alberta range, and have now crossed over the Saskatchewan border through Cypress Hills Interprovincial Park, an oasis of forest surrounded by prairie. Formerly carnivore-free, the park supports numerous mammals including an abundant ungulate population, which, prior to the return of cougars, was controlled only by a yearly elk hunt.

The expansion of cougars' eastern range means that management and conservation strategies are needed to protect the human, livestock, and wildlife interests of the area. This research project is designed to determine the habitat and prey selection of the newly re-established cougar population in Cypress Hills Interprovincial Park. The objectives are to: 1) determine the composition and distribution of the population of cougars in this region, 2) evaluate the seasonal and human effects on movement and range of the cougars, and 3) determine the composition of prey-including livestock killed by cougars in this region. We will use GPS radio collars to track movement and investigate kill sites. Digital remote cameras and historical aerial survey data will help us assess prey abundance and distribution. We will create habitat models using GPS telemetry data to demonstrate the relative probability of use by cougars of the Cypress Hills landscape.

There are currently no management guidelines for cougars in eastern Alberta or Saskatchewan, and as the current laws allow private landowners to kill cougars on their property, it is important to quantify the population of the region so that managers can make informed decisions. Evaluating this isolated population also will help gain an understanding of factors that contribute to the restoration of a large carnivore, and will provide insight into potential expansions of cougars into more eastern parts of North America.

## **Generating an Index of Relative Abundance for Cougars Throughout the Jackson Hole, Wyoming, Area Using Winter Tracking Methods**

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**ABSTRACT** Although traditional techniques of field naturalists are sometimes overshadowed by newer and more technology-intensive methods, slight adaptations in these traditional techniques often can meet the demands of modern wildlife science (Beauvais and Buskirk 1999). Track monitoring on a snow substrate may be a useful method, especially for monitoring rare and wide-ranging mammalian species in northern latitudes where adequate snow conditions may persist for several months of the year. Species found in these areas are generally very difficult to survey with any statistical validity at any other time of the year due to rugged terrain, inconsistent tracking medium, and the ability of many species to traverse through the habitat without leaving easily detectible sign. Species are readily identified by characteristics of tracks (single footprints) and trails (sequences of tracks made by single animals) (Murie 1974). Snow preserves a relatively continuous record of animal movements between successive snowfalls (Beauvais and Buskirk 1999). Furthermore, snow tracking surveys have been used to generate indices of relative abundance for rare or wide-ranging species such as cougars.

Managers and researchers have often found it difficult to monitor changes in cougar populations because cougars are largely nocturnal, secretive, and occur at low densities (Beier and Cunningham 1996). The Rocky Mountain region of the western United States and Canada is especially difficult for researchers to successfully conduct reliable surveys of cougar populations. The vast, rugged terrain and expansive, unbroken wilderness found throughout the region make accurate survey results nearly impossible without the allocation of large amounts of time, money, and effort. To monitor cougar populations at the lowest cost, managers have used collaborative data from hunter harvest, depredation rates, and track surveys (Beier and Cunningham 1996). Recent studies have tested the use of remote camera stations (Kelly et al. 2008). Confirmed sightings by the public have also been included in assessing cougar abundance.

Several studies have applied and tested the use of snow tracking methods (Choate et al. 2006, Stephens et al. 2006, Beauvais and Buskirk 1999, Hayward et al. 1996, Halfpenny et al. 1995, Van Sickle and Lindzey 1991) for monitoring low-density populations of large carnivores. Those studies have helped determine conditions required to increase the usefulness of such surveys. Two design variables have been determined to explain a high amount of variability in track detection rates: route length and the number of days since the last snowfall (Hayward et al. 1996). These 2 variables play important roles in the accuracy and reliability of survey data.

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## **Movements of a Female Cougar on the Human-Wildlands Interface**

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**ABSTRACT** One of the most difficult but important aspects of large carnivore conservation will be the development of data about carnivore use of areas in and around human development. Human tolerance of large carnivores will be dependent on this understanding. Unfortunately, very little specific, empirical data are available on the use of these interface habitats. Cougars are the most widely distributed large carnivore in the Western Hemisphere. They not only occur in some of the wildest habitats, but are also well-established in human-dominated landscapes. Thus, information on cougar movements and behaviors in these situations could be key to cougar survival in these landscapes, and provide new understanding for the development of long-term carnivore conservation worldwide. The Craighead Beringia South-Teton Cougar Project has been intensively tracking cougar movements in the Jackson Hole Wyoming area since 2001. The majority of the study animals have used wild lands and wilderness landscapes. However, use of areas around human development has been well documented for several study animals. This poster presents specific movement information on one subadult female cougar. This cougar, estimated to be 3 years of age, utilized areas on the edge of the town of Jackson for approximately 10 months. We provide specific information about rates of movement, distance to human habitation, and distance to roads.

## Estimating Cougar Population Abundance in Northeast Oregon

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**ABSTRACT** Cougars (*Puma concolor*) are wide-ranging, long-lived, and very secretive. Like other large carnivores, obtaining reliable estimates of cougar population densities is difficult. As part of a large study on factors influencing calf recruitment of Rocky Mountain elk (*Cervus elaphus*), we estimated population densities of cougars, thus far over a 6-year period in 2 study areas of northeast Oregon. To determine population densities we used a capture-recapture (Lincoln-Petersen) estimator and a reconstructed population method at three different spatial scales. These results were compared to minimum population estimates of all adult (male and female) and subadult female cougars derived from radiocollaring individuals in each study area. We discuss the challenges of estimating population densities of cougars, reliability of different approaches, and management implications of our findings.

## **Survival and Ages of Cougars Harvested After Cougar Hunting With Dogs Was Banned in Oregon**

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**ABSTRACT** Cougar (*Puma concolor*) management changed in Oregon when Ballot Measure 18 passed in 1994, making it unlawful to use dogs for cougar hunting. In addition to Ballot Measure 18, several other changes were made that impacted cougar management in the state. The Oregon Department of Fish and Wildlife (ODFW) Commission changed cougar hunting from controlled hunts with a limited number of hunters having access to trained dogs, to a statewide season with unlimited tags beginning in 1995. The hunting season was also expanded from 2 ½ to 4 months in 1994, and then to 7 months in 1995. The Oregon Legislature reduced the price of a cougar tag from \$50.00 to \$10.00 in 1997. Also in 1997, the Sport Pac license was developed for Oregon residents and it included a cougar tag with purchase of the license package. By 2001, the general cougar hunting season had been expanded to 10 months within the calendar year. ODFW also instituted a quota-based system of harvest management. Beginning in 2005, hunters could harvest a second cougar in all of eastern Oregon.

Data will be presented from a statewide perspective and also from three intensive research studies conducted within the state. We will discuss changes to survival and ages of cougars harvested in response to the initiative that banned using dogs to hunt cougars. Additionally, we will discuss statutory and regulatory changes implemented since 1994 that have affected cougar management in Oregon. Initially, cougar harvest declined after the use of dogs was prohibited. In recent years, although cougar harvest has increased to levels observed prior to 1994, the proportion of total statewide cougar mortality caused by hunters has declined. Concurrent with the decline in harvest, the proportion of total cougar mortality attributed to hunting fell below 50% of the total known mortality for several years. Age composition of the harvest has also changed. With dogs available for hunting, hunters took mostly older male cougars, whereas without the use of dogs, the median age of cougars taken by hunters has declined. Overall annual survival appears higher now compared to when dogs were used to hunt cougars. However, numbers of cougars illegally killed may have increased.

## Research and Educational Efforts by the Cougar Network

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**ABSTRACT** The goal of this poster is to showcase the non-profit Cougar Network's efforts to document cougar presence east of their established range, conduct research on cougar ecology and human dimensions, and provide wildlife biologists and the general public with training and information. Since 2003, the Cougar Network has consulted with its board of scientific advisors, wildlife agencies, universities, and other wildlife biologists to collect definitive evidence (e.g., carcasses, photographs) of cougar (*Puma concolor*) presence east of their established range. This database represents the foremost repository of information regarding cougar confirmations in the Midwest, and is highly valued by wildlife biologists and the public alike. Scientific research efforts conducted thus far by the Cougar Network, in conjunction with Southern Illinois University of Carbondale, include: (1) prediction of suitable cougar habitat and dispersal corridors in 9 midwestern states, (2) a survey of human attitudes towards cougars in 2 midwestern states, and (3) a study of jaguar (*Panthera onca*) and cougar occupancy in relation to livestock operations in Sonora, Mexico. The Cougar Network is also active in training wildlife biologists (especially those from the Midwest and East with little cougar experience) by conducting cougar field workshops. The Cougar Network has also printed the latest Puma Field Guide and publishes Wild Cat News, an acclaimed newsletter that summarizes a variety of felid research and management projects conducted worldwide. These efforts have contributed to our understanding of cougars and other Felidae, especially in the Midwest, and will help wildlife biologists face present and future management challenges.

## **Intra-specific Variation in Cougar Behavior in the Southern Greater Yellowstone Ecosystem**

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**ABSTRACT** Cougar behavior, as well as mammal behavior, is considered to be relatively static in terms of the social interactions, social tolerance, and spacing behavior. However, this lack of variation may be a reflection of the lack of intensive research. New technology for tracking cougars and other wildlife has provided opportunities to document more fully the interactions between cougars. We present several examples of how intensive, day-to-day tracking and new technology have provided documentation of heretofore little-documented behaviors for cougars. We provide evidence for cougar interactions gathered in the southern greater Yellowstone ecosystem. For example, a female cougar and her male kitten visited her adult offspring and kittens in the summer of 2006 and the two family groups spent several days together. The adult cougar and kittens were visited while feeding on an elk by an adult male; the two adults and three kittens apparently tolerated each other at the kill site. The adult male and the three kittens were captured and collared at that site. After the adult female was legally harvested, her three large kittens (approx. 14 mo. of age) traveled with a family group of an adult female and three kittens of approximately 6 months of age. These types of intra-specific behaviors, although uncommon, may change the understanding of cougar social interactions and spacing behavior.

## Mountain Lion Movements Relative to Development, Roads, and Trails in a Fragmented, Urban Landscape

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**ABSTRACT** Habitat loss and fragmentation due to urbanization can have significant impacts on wildlife movement and survival. Large carnivores, such as mountain lions (*Puma concolor*), are especially vulnerable to the effects of urbanization because of their extensive spatial requirements, low density, and potential for conflicts with humans. Since 2002, we have been using GPS collars to study the behavior, ecology, and conservation of mountain lions in and around Santa Monica Mountains National Recreation Area, a national park west of Los Angeles. Collars have generated over 30,000 locations for 8 mountain lions and allowed us to collect detailed information on activity and movement patterns. We measured the degree to which mountain lions used developed areas, altered open lands (golf courses, low-density residential areas, landscaped parks, etc.), and areas within various distances (100, 250, 500, and 1000m) from urbanization. On average, mountain lion home ranges included less developed area or habitat close to development and more area >1km from development than the study area as a whole (e.g., 48% of home ranges consisted of area >1 km from development vs. 40% of the study area). However, 3 mountain lions utilized urban and altered areas significantly more than other animals, with home ranges consisting of more than 10% developed area. One of these lions made multiple trips into habitat fragments that were isolated from core park areas by roads and development, and another showed increased use of highly urbanized areas while attempting to disperse. Mountain lions regularly crossed all of the major 2-lane paved roads through the Santa Monica Mountains. Although in some instances crossings occurred under roads along streams, or over roads above tunnels, most of the road crossings were on the road. Two male lions were killed along one stretch of road during the 5 years of our study. GPS locations and track counts show that mountain lions will move along recreational roads and trails frequented by people, but mostly at night when human activity is low. Most mountain lion travel routes were in the dense brush along game trails and on gentle slopes or in canyon bottoms. Even though mountain lions utilized habitat near urban areas with many roads and trails and recreating humans, there have been minimal encounters and conflicts with people.

## **Cougars in British Columbia: Conservation Assessment and Science-Based Management Recommendations**

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**ABSTRACT** At present, British Columbia (BC) lacks a comprehensive cougar management strategy. In anticipation of a new management plan, British Columbians have an opportunity to contribute to cougar conservation. Based on our review of cougar ecology, research and management in BC and elsewhere, we provide a comprehensive conservation assessment that supports a science-based cougar conservation plan for BC. We find that current provincial management policies, which depend on hunting regulations only, likely are inadequate to protect cougar populations and habitat in the long-term. Accordingly, we provide a set of ‘best’ principles of precautionary harvest management. Specifically, we recommend moving from a general open cougar hunting season to low male quotas and very low female quotas. Moreover, populations in BC should be managed within a framework that better reflects a metapopulation structure. We note, however, studies consistently show most British Columbians do not support trophy hunting of large carnivores. In addition, our review suggests that long-term conservation strategies for BC cougars should include the protection of a large network of connected habitat for cougars and their prey. We conclude by highlighting several urgent research priorities, among them the initiation of a study in coastal BC where cougar-human conflict is particularly severe.

## Safety and Effectiveness of Cage Traps for the Capture of Cougar

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**ABSTRACT** Safe and effective capture of cougar (*Puma concolor*) is a critical component of successful research and management efforts. Use of trained dogs provides an efficient and effective means to capture cougar, but may result in serious injury or death to animals or project personnel. As part of an ongoing study of cougar-human interaction in western Washington, we are utilizing large (1.3m x 1.3m x 3m), steel cage traps to supplement capture efforts using dogs. From Dec. 1-Mar. 31 traps are placed in areas of known cougar use and baited with road-killed black-tailed deer (*Odocoileus hemionus columbianus*), elk (*Cervus elaphus*), or nuisance-trapped beaver (*Castor canadensis*). Traps are concealed using vegetation and materials found on site and one of two varieties of commercial scent lure are applied to surrounding trees. To date, we have captured a total of 9 cougars (7 males, 2 females) 14 times. Catch per unit effort (CPUE) has been variable: 2004-2005: 1 cougar/34 trap nights; 2005-2006: 1 cougar/50 trap nights; 2006-2007: 1 cougar/72 trap nights. Use of cage traps for scavenging cougar has a male bias ( $\chi^2 = 4.571$ ,  $P = 0.38$ , 1 df), and individual males can be captured multiple times whereas females are unlikely to be recaptured. An additional 3 cougars (all female) were captured with traps baited using cougar-killed deer, elk, or livestock. Injuries associated with cage traps were infrequent and most often consisted of minor cuts and abrasions to the head and face and minor damage to the front claws. Claw damage was eliminated with the placement of a layer of felt, 1.4cm plywood, or vegetation/dirt on the floor of the trap. Only one tooth breakage associated with the use of the cage has been documented with an adult female breaking < 2.0 cm of an upper canine. Advantages of cage traps include ease of use, year-round use, and increased safety for project personnel and captured cougar. Disadvantages include size and weight of traps, limited placement of traps beyond road edges, and initial cost for trap construction (~\$4500-\$6500). Overall, we believe cage traps provide a very safe and effective means to capture cougar for research and management projects and can be valuable tools to supplement capture efforts with dogs.

## Cougar-Induced Vigilance in Ungulate Prey: Does Predator Proximity Matter?

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**ABSTRACT** Trading foraging time with increased vigilance is widely attributed to the threat of predation. Numerous studies examining the relationship between vigilance and other factors (e.g., prey's herd size, habitat use) suggest that clear patterns are elusive and that vigilance per se may be highly plastic. If vigilance is costly by reducing feeding time, prey should reduce vigilance as the distance to a predator (or threat) increases, resulting in a scaled response even within factors (e.g., specific habitat types). In this study we used focal sampling of foraging bouts by 3 species of ungulates that differed in body size and anti-predator defenses (elk, *Cervus elaphus*; mule deer, *Odocoileus hemionus*; and white-tailed deer, *O. virginianus*), to determine whether proximity of a stalking/ambush predator (cougar, *Puma concolor*) influences time spent vigilant while foraging. For all 3 species males spent less time vigilant than females. There was no evidence for a herd-size effect on vigilance for any species, but white-tails displayed a significant decline in vigilance with increasing distance to cougars. Both deer species responded to the presence of a cougar within the same drainage or "viewshed", by decreasing vigilance levels with increasing distance. When cougar were outside of the viewshed, there was no longer a relationship between cougar proximity and vigilance levels. Prey-specific anti-predator responses to cougar, a stalking predator, suggest that generalizations of vigilance to other predator types (e.g., coursing predators) is inappropriate, and that vigilance as a metric for determining population levels of predation risk may be less appropriate for communities with low-density solitary felids such as cougar, except at very small (i.e., within viewshed) temporal-spatial scales.

## Variation in the Reproductive Success of Female Cougars by Individual Traits, Density, and Seasonal Weather.

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**ABSTRACT** The vital rates (fecundity, survivorship) and migration rates of an animal population determine its size and composition, and represent the combined life-history performances of its constituents. Understanding how individual traits, population characteristics, and extrinsic factors influence fecundity and survivorship is fundamental to explaining the dynamics of a population. It can also reveal valuable insights about the species' life-history strategies. In addition, being able to predict changes in vital rates, based on known associations with key explanatory variables, is important when managing for a stable population.

To examine how the short-term reproductive success of adult female cougars varied with an individual's identity (i.e., age, size) and behavior (i.e., habitat use), conspecific density, and weather, we analyzed long-term data of a hunted population of cougars in SW Alberta studied by Jalkotzy and Ross during 1981-1994. We developed generalized-linear models to identify different influences on female reproductive output. Habitat use was measured in a novel way, which accounted for extreme behavior, and out-performed measuring the average habitat used.

Productive females were older and frequented habitats with <32% closed-canopy cover (>49% open-canopy cover) within 1.0 km<sup>2</sup> of a female's location. Productivity varied negatively with the density of independent cougars. Litter sizes were large when mothers occupied mid-elevation habitats (summer: 1437-1745 m, winter: 1445-1678 m). Female-biased litters were reared when cougar density was low or when mothers experienced harsh conditions: cold snowy winters and springs or poor-quality habitat. Plausible explanations for sex-biased litters are presented.

Future challenges: Further studies are needed to investigate the mechanism by which a mother rears a sex-biased litter; links between reproductive output, adult female physiology, and habitat and weather conditions; and, density-dependent effects on offspring sex ratios.

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