PROCEEDINGS OF
THE FIFTH MOUNTAIN LION WORKSHOP

27 FEBRUARY - 1 MARCH 1996
SAN DIEGO, CALIFORNIA

ORGANIZING COMMITTEE

Lorna Bernard  Terry Mansfield
Slader Buck     David Mayer
Shana Dodd      Brock Ortega
Karen Kirtland  Doug Padley
Carolyn Lincer  Scott Taylor
Jeff Lincer     Steve Torres
Steve Loe       Doug Updike

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PREFACE

The idea of a mountain lion workshop originated in 1976 when several western states, provinces and federal agencies gathered in Reno, Nevada to share information that had been collected on the mountain lion and to establish both standards for collecting information and determine what research was needed to answer appropriate questions. Over the ensuing 20 years there have been a total of five workshops which have built on the foundation set by the first workshop. The character and types of information presented at these workshops has changed considerably in the last 20 years. Because the number of people involved with the mountain lion has increased and because the amount and scope of research has blossomed, the format of the workshop has evolved into a more formal conference format.

The Southern California Chapter of The Wildlife Society and the California Department of Fish and Game worked cooperatively to organize and manage the Fifth Mountain Lion Workshop. The initial steps were to determine if there was sufficient interest in holding another workshop. After conducting a survey of biologist and managers in the field we were surprised at the level of interest expressed by everyone. With this information we moved forward with raising funds, identifying a location to hold the workshop and developing a mailing list. Fortunately no matter who we asked for help they agreed to participate. With all this help we were able to manage all of the logistics associated with the workshop.

A workshop like this would not be possible without the time, effort, and perseverance of many biologists from across the North and South American continents. Without the biologists spending the time in the field and managers backing their activities none of this would have been possible. The Fifth Mountain Lion Workshop is a forum for these biologists and managers to present their findings and to engage each other in discussions about mountain lions. To this end I believe we succeeded.

Presented in the following pages are papers presented at the workshop and submitted for publication in these proceedings. We also present the abstracts of those who wanted their abstracts published. In order to keep track of papers that have been published elsewhere we have included a reference section of papers that were presented at the workshop and published elsewhere. Finally we have included the state and provincial status reports and a list of participants. I hope this information will be useful to those working with mountain lions.

W. Douglas Padley
Editor
ACKNOWLEDGMENTS

The Fifth Mountain Lion Workshop was organized by a committee from the Southern California Chapter of the Wildlife Society and the California Department of Fish and Game. Terry Mansfield of the Department agreed to cosponsor the workshop in 1994 and assigned Steve Torres and Doug Updike to work on the project. Steve acted in the capacity as Co-Chairman of the workshop and was instrumental in organization of the program and in the review and publication of the workshop proceedings. Doug Updike coordinated activities with state and provincial agencies. The standardized format for the status reports was Doug’s idea. Lorna Bernard worked with the media to keep the public informed of the conference and to insure there would be no disruption of the conference by media coverage. The guidance activities of these Department employees insured a successful program.

Carolyn and Jeff Lincer have worked on organizing conferences for other organizations and volunteered to negotiate and manage a contract with the Bahia Hotel. The accommodations, the conference facilities, and the management of those facilities was done very well. Shana Dodd and Slader Buck agreed to managed the registration process. Not only were most people registered prior to the meeting, those that chose to register at the conference were processed efficiently. Karen Kirtland, Steve Loe, David Mayer, Brock Ortega, and Scott Taylor worked behind the scenes working on logistics to prepare for the workshop and to head-off problems that might arise during the conference. Students from San Diego State University ran the slide projectors and acted as gophers during the workshop.

The workshop and the proceedings would not have been possible without the support of several organizations. The San Diego County Fish and Wildlife Advisory Commission, The Wildlife Society, the Western Section of The Wildlife Society, and the Southern California Chapter of The Wildlife Society all contributed funds to cover workshop expenses. The California Department of Fish and Game and the San Bernardino National Forest both contributed services in lieu of funds.

We would like to take this opportunity thank all of the biologists and managers that have taken an interest in the mountain lion and have made these workshops possible. In particular we would like to say thank you to the biologists and managers that prepared papers for the Fifth Mountain Lion Workshop.

W. Douglas Padley
Steve Torres
Workshop Co-Chairmen.
MEMORIAL
Allen was born March 17, 1927, in Duluth, Minnesota, to Walter and Anna Hancock Anderson. His father worked as a mechanical engineer and his mother as a secretary before her marriage. Allen graduated from Vallejo Senior High School in Vallejo, California, in 1944. Intent on becoming a writer, he joined the Merchant Marine after high school to see the world and gain experience about which to write. Two years later, Allen quit the Merchant Marine and enlisted in the U.S. Army.

After serving in Korea with the Army prior to the Korean War, he attended Colorado A & M, now Colorado State University, in Fort Collins on the G.I. Bill. While working on a winter class project in the mountains in early 1951, he suffered severe frostbite on both feet. All the toes on his left foot were amputated and he spent about nine months at the Veterans Administration Hospital in Cheyenne, Wyoming, recuperating. One of his nurses at the hospital was Marilu Soper, who grew up on a ranch south of Custer, South Dakota. The two were married December 15, 1951, in Custer. Allen graduated from Colorado A & M with a bachelor of science degree in game management in 1953 and from CSU with a master of science degree in wildlife management in 1960.

During his professional career, Allen studied primarily mule deer ecology, first in the Guadalupe Mountains of New Mexico and then in the Poudre River and Big Thompson River drainage areas west and southwest of Fort Collins. The last research project he undertook before officially retiring from the Colorado Division of Wildlife in 1991 dealt with mountain lion, or pumas as he preferred to call them, on the Uncompahgre Plateau near Montrose. After his "retirement," Allen continued his research and was updating his 1983 critical review of the scientific literature on puma at the time of his death.

In his 40s, Allen took up bicycle racing, a longtime dream. Bicycling continued to be an important part of his life after he quit racing. He toured for many years, going on long rides alone or with friends. When his arthritis made riding standard bikes too painful, he switched to a recumbent bike. On that bike, he rode from Montrose to Vallejo when he was 61.

Through the hard times of his life, such as bad bouts of arthritis and later heart problems, Allen relied on Marilu, jazz, books (especially the works of S.J. Perelman and James Thurber), the wonders of the natural world, and later, time with his grandchildren, to carry him through.

He was preceded in death by his parents and granddaughter, Chelsea Anderson. He is survived by his wife, Marilu Anderson, two daughters, a son, a sister, a brother, and five grandchildren.
KNUT ATKINSON

Knut Atkinson and fellow biologist Rick Davies disappeared on October 18, 1996 while attempting to cross Downton Lake, near Gold Bridge, on the start of a hunting trip. A long time friend of the Atkinson family, Jack Morton, was also part of this ill-fated trip.

Knut spent most of his career working on Vancouver Island for the Wildlife Management Section of BC Environment. He became a member of our work family in 1982, as field biologist on a wolf research project. Knut was just completing his post graduate study on coyotes, had the qualifications we were looking for, and quickly became a resident of Woss, a small logging community on northern Vancouver Island.

During the 4 year project, Knut proved that he possessed the necessary skills and character to successfully conduct a rigorous and at times controversial project. He displayed an intense desire to learn as much as possible about our wildlife heritage, both through field observation and the literature, and gained the respect of his peers, conservation officers, and wildlife enthusiasts throughout the province.

Being a very social person, living on his own in relative isolation was not easy for Knut. We provided him with a trailer, and the money he saved on accommodation went toward his large telephone bills. He loved having visitors, although the trailer was so full of records and books it was a challenge to find a place to sit. It was during this time that Knut established his reputation for hard rock music, sci-fi literature, and a somewhat questionable taste in wine!

Following completion of the wolf study, Knut became the regional carnivore biologist, working primarily on black bear, grizzly bear, wolf and cougar management. In 1989 he initiated a study on cougar ecology and behavior, and ensured its success through his dedication and perseverance. His passion and knowledge of these large carnivores made him a leading expert in this field. The cougar project also established his reputation as a marksman. On one particular day, Knut and his field assistants treed a large male, and after several 'near hits', as Knut called them, the cat was finally hit with a dart and immobilized. An assistant climbed the tree and was in the process of lowering the cat to the ground, when it began to regain mobility. Calling for another dart to be shot, the assistant looked down at Knut's wavering aim, and recalling the previous 'near hits', yelled down "never mind. I'll take my chances with the cat!".

In addition to his network with professional colleagues across North America, Knut had a special talent for communicating with the general public and young school children. He enjoyed the opportunity to visit schools and share his knowledge and experience with the children, and was frequently called upon by the media for information on bears, cougar, and wolf. This talent was most appreciated by fellow co-workers during those stressful situations associated with human/cougar confrontations resulting in serious injury or death.

Recently, Knut initiated a study on inventory techniques for grizzly bear on the mainland coast, and organized a new cougar study to be started this winter. We hope to continue and fully implement these projects in 1997, as an ongoing tribute to Knut's contributions.

Knut enjoyed hunting, hiking, and camping with family and friends. He was a loving husband to Bea, and a proud father of daughter Lorien (4) and son Liam (2). Outspoken and gregarious, his good humor and friendship will be missed by all.

Doug Janz, Wildlife Section Head
Gerry Brunham, Wildlife Control Offices
BC Environment, Nanaimo, BC
PROCEEDINGS OF THE FIFTH MOUNTAIN LION WORKSHOP

PROGRAM

TUESDAY FEBRUARY 27, 1996

5:00 PM - 9:00 PM Registration

WEDNESDAY FEBRUARY 28, 1996

7:00 AM - 5:00 PM Registration

Session One: Opening Session
W. Douglas Padley, Santa Clara Valley Water District, Chair
8:30 - 10:00

8:30 Announcements and Introductions
8:35 Welcoming Address: C.F. Raysbrook, Interim Director, California Department of Fish and Game
8:50 Welcoming Address: Jeffrey Lincer, President, Southern California Chapter, The Wildlife Society
9:10 FACES OF OUR NEIGHBORS. Susan Morse.
9:20 Keynote Address: Howard Quigley, Hornocker Wildlife Institute, Inc.
9:45-10:00 Break

Session Two: Status Reports
Doug Updike, California Department of Fish and Game, Chair
10:15-12:00

10:15 British Columbia. Knut Atkinson
10:30 Washington. Steve Pozzanghera
10:45 Oregon. Jim Henjum
11:00 California. Steve Torres
11:15 Arizona. John Phelps
11:30 Nevada. Mike Cox
11:45 Idaho. John Beecham
12:00-1:15 Lunch

Session Three: Status Reports
Shana C. Dodd, Shana C. Dodd Biological Research and Consulting, Chair
1:15-2:45

1:15 MOUNTAIN LION MANAGEMENT IN MONTANA. John J. McCarthy
1:30 Wyoming. Roger Bredhoft
1:45 Colorado. Tom Lytle
2:00 Utah. Boyde H. Blackwell
2:15 Texas. William B. Russ
2:30 Florida. Robert C. Belden
2:45-3:15 Break

Session Four: Techniques
Vern Bleich, California Department of Fish and Game, Chair
3:15-5:00

3:15 THE FORT HUACHUCA/CANELO HILLS TRACK COUNT: A MODEL FOR VOLUNTEER-BASED MOUNTAIN LION MONITORING. H. Sheridan Stone, David Coblentz, Susan Morse, Kevin Hansen, and Harley Shaw.

3:30 FEASIBILITY OF USING CAPTIVE-RAISED MOUNTAIN LIONS FOR ESTABLISHING POPULATIONS. Robert C. Belden, and J. Walter McCown.

3:45 PHOTOGRAPHIC RECORDING OF MOUNTAIN LION TRACKS. K. Shawn Smallwood, and Melissa Grigione.

4:00 TEN YEARS OF CALIFORNIA MOUNTAIN LION TRACK SURVEY. K. Shawn Smallwood, and Bruce Wilcox.

STUDY AND INTERPRETIVE DESIGN EFFECTS ON MOUNTAIN LION DENSITY ESTIMATES. K. Shawn Smallwood, and Bruce Wilcox.

4:15 TESTING OF 'A RIGOROUS TECHNIQUE FOR IDENTIFYING INDIVIDUAL MOUNTAIN LIONS (Puma concolor) BY THEIR TRACKS.' Melissa M. Grigione.

4:30 A DEVICE TO SAFELY REMOVE IMMOBILIZED MOUNTAIN LIONS FROM TREES AND CLIFFS. Jeff L. Davis, Cheryl-Lesley B. Chetkiewicz, Vernon C. Bleich, Gleb Raygorodetsky, Becky M Pierce, Jeffrey W. Ostergard, and John D. Wehausen.

4:45 FEEDING HABITS OF MOUNTAIN LIONS INVESTIGATED USING REMOTE PHOTOGRAPHY AT CACHED PREY SITES. Becky M. Pierce, Vernon C. Bleich, Cheryl-Lesley B. Chetkiewicz, and John D. Wehausen.

5:00-7:00 Dinner Break

Reception, Posters, and Video Tapes
7:00-10:00

VIDEO TAPES

Cougar Crisis. Mathew Todd Paproski.

California Department of Fish and Game field tape.
POSTERS

STANDARDIZING PHOTOGRAPHS OF PUMA TRACKS FOR DIGITAL PROCESSING. Steve Galentine, and E. Lee Fitzhugh.

SOURCES AND DISTRIBUTION OF PROPOSITION 117 FUNDS. E. Lee Fitzhugh.

THURSDAY FEBRUARY 29, 1996

7:00-8:30 Continental Breakfast

Session Five: Mountain Lions, Bears, Wolves, and Bighorn Sheep
Doug Updike, California Department of Fish and Game, Chair
8:30-10:00

8:30 LION-BLACK BEAR INTERACTIONS: A SURVEY FOR PARTICIPANTS. Hal L. Black and Jerran T. Flinders.

8:45 INTERACTIONS BETWEEN COUGARS AND WOLVES (AND A BEAR OR TWO) IN THE NORTH FORK OF THE FLATHEAD RIVER, MONTANA. T.K. Ruth, and M.G. Hornocker.

9:00 ECOLOGICAL RELATIONSHIPS BETWEEN BEARS AND PREDATION BY COUGARS ON UNGULATES. Kerry M. Murphy, Gregory S. Felzien, Maurice G. Hornocker, and Toni K. Ruth.

9:15 EFFECTS OF COUGAR (Puma concolor) PREDATION ON DESERT BIGHORN SHEEP (Ovis canadensis) IN THE SAN ANDRES MOUNTAINS, NEW MEXICO. Kenneth A. Logan, L.L. Sweanor, and M.G. Hornocker.

9:30 MOUNTAIN LION PREDATION ON BIGHORN SHEEP IN THE PENINSULAR RANGES OF CALIFORNIA. Esther Rubin, Walter Boyce, Charles Hayes, Steve Torres, and Mark Jorgensen.

9:45 MOUNTAIN LION IMPACTS ON BIGHORN SHEEP POPULATIONS. John D. Wehausen.

10:00-10:15 Break

Session Six: Cougar Food Habits
Slader Buck, Marine Corps Base, Camp Pendleton, Chair
10:15-11:30

10:15 WINTER FOOD HABITS OF COUGARS IN SOUTHWESTERN ALBERTA. Martin G. Jalkotzy, P. Ian Ross, and Ralph W. Schmidt.

10:30 MORTALITY OF MULE DEER IN THE WESTERN GREAT BASIN: THE ROLE OF PREDATION BY MOUNTAIN LIONS. Vernon C. Bleich, Timothy J. Taylor, and Becky M. Pierce.

10:45 MOVEMENTS AND DIETS OF MOUNTAIN LIONS IN SOUTHWESTERN ARIZONA. M.F. Peirce, and J.L. Cashman.

11:00 PREY AVAILABILITY AND SELECTION BY MOUNTAIN LIONS IN THE ARAVAIPA-KLONDYKE AREA OF ARIZONA. Stan Cunningham.

11:15 MOUNTAIN LION FOOD HABITS IN A DESERT ENVIRONMENT: PRELIMINARY RESULTS. Mike Elmer, K.A. Logan, L.L. Sweanor, and Maurice G. Hornocker.
11:30  NECROPSYING MOUNTAIN LIONS INVOLVED IN FATAL OR NEAR FATAL HUMAN ATTACKS: THE BENEFITS OF PROTOCOL AND INTERAGENCY NETWORK.  Bradd C. Barr, Pamela K. Swift, William E. Clark, and Alex Ardans.

11:35-1:00  Lunch

**Session Seven: Forensics, Genetics, and Taxonomy**
James Banks, California Department of Fish and Game, Chair
1:00-3:00

1:00  THE ROLE OF INFECTIOUS DISEASE IN POPULATION CONTROL AND REGULATION OF WESTERN MOUNTAIN LIONS.  Janet Foley.

1:15  ASSESSING SUBSPECIFIC STATUS: A HOLISTIC APPROACH TO EVALUATING THE YUMA PUMA.  Donald E. McIvor, and John A Bissonette.

1:30  CONTRIBUTION TO THE IDENTIFICATION OF *Puma concolor concolor*.  Marcelo Mazzolli, and Catherine Bartlet Ryan.


2:00  CHARACTERIZATION OF GENETIC VARIATION IN THE PUMA (*Puma concolor*).  Melanie Culver, Marilyn Raymond, Warren Johnson, Melody Roelke, and Steve O'Brien.

2:15  DNA FROM MOUNTAIN LION SCAT: PRELIMINARY STUDIES.  Holly Ernest, Michael Syvanen, and Walter Boyce.

2:30  FORENSICS INVESTIGATION TO IDENTIFY PERPETRATING MOUNTAIN LIONS IN TWO SEPARATE FATAL ATTACKS ON HUMANS IN CALIFORNIA.  James Banks, Kenneth Levine, and Michael Syvanen.

3:00-3:15  Break

**Session Eight: Movements and Behavior**
Kenneth Logan, Hornocker Wildlife Research Institute, Inc., Chair
3:15-5:00

3:15  DIURNAL BEDDING HABITAT OF MOUNTAIN LIONS IN NORTHEAST OREGON.  James Akenson, Mark Henjum, and Ted Craddock.


4:00  DISPERsal of JUVENILE COUGARS IN FRAGMENTED HABITAT.  Paul Beier.

4:15  DISPERsal of COUGARS (*Puma concolor*) IN METAPOPULATION DYNAMICS.  Linda L. Sweanor, K.A. Logan, and M.G. Hornocker.

4:30  POWER OF TRACK SURVEYS TO MONITOR POPULATION TREND.  Paul Beier, and Stan C. Cunningham.
4:45 SOCIAL ENCOUNTERS AMONG MOUNTAIN LIONS (*Puma concolor*) IN THE SANTA ANA MOUNTAINS, CALIFORNIA. W. Douglas Padley.

5:00-6:00 Break.

6:00-7:00 Sunset Cruise on Mission Bay.

7:00-10:00 Banquet and Entertainment.

**FRIDAY MARCH 1, 1996**

7:00-8:30 Continental Breakfast

**Session Nine: Ecology**  
Jeffrey Lincer, Sweetwater Environmental Biologists, Inc., Chair  
8:30-10:00

8:30 FEMALE MOUNTAIN LION (*Puma concolor*) HOME RANGES IN THE SOUTHERN SANTA ANA MOUNTAINS, CALIFORNIA. W. Douglas Padley.

8:45 MOUNTAIN LION RESEARCH IN TEXAS: PAST, PRESENT AND FUTURE. Louis Harveson, Michael E. Tewes, and Jimmy C. Rutledge.

9:00 ECOLOGY OF MOUNTAIN LIONS ON BIG BEND RANCH STATE PARK IN TRANS-PECOS TEXAS. Michael T. Pittman, Billy Pat McKinney, and Gilbert Guzman.


9:45 MOUNTAIN LION (*Felis concolor*) VOCALIZATIONS IN THE SANTA ANA MOUNTAINS, CALIFORNIA. W. Douglas Padley.

10:00 Break.

**Session Ten: Populations**  
Paul Beier, Northern Arizona University, Chair  
10:15-12:00


10:30 TRENDS IN LION MORTALITY, WESTERN UNITED STATES. E. Lee Fitzhugh, and Allen E. Anderson.

10:45 CALIFORNIA STATEWIDE ESTIMATES AND TREND ANALYSIS: LESSONS FROM THE DIABLO RANGE. Rick A. Hopkins.

11:00 IMPLICATIONS OF MOUNTAIN LION MOVEMENTS FOR POPULATION REGULATION AND CONSERVATION. Becky M. Pierce.
11:15  POPULATION DEMOGRAPHICS OF AN EXPLOITED POPULATION IN ARIZONA.  Stan Cunningham.

11:30  THE QUOTA SYSTEM OF COUGAR HARVEST MANAGEMENT IN ALBERTA.  P. Ian Ross, Martin G. Jalkotzy, and John R. Gunson.

11:45  SPATIAL-TEMPORAL ANALYSIS OF MOUNTAIN LIONS IN THE SIERRA NEVADA: LOOKING FOR PATTERN AND "BULLS-EYES" AMID THE MESS.  Eric Loft.

12:00-1:15  Lunch

Session Eleven: Human Interactions, Public Awareness and Attitudes,
David Mayer, Merkel and Associates, Chair
1:15-2:45

1:15  COUGAR CRISIS.  Mathew Todd Paproski.

1:30  SUGGESTED HUMAN RESPONSES TO DIFFERENT PUMA BEHAVIORS.  E. Lee Fitzhugh, and David P. Fjelline.

1:45  COUGAR RESPONSES TO HUMAN ACTIVITY AT SHEEP RIVER, ALBERTA.  Martin G. Jalkotzy, and P. Ian Ross.

2:00  SOCIETAL PREFERENCES FOR MOUNTAIN LION MANAGEMENT ALONG COLORADO'S FRONT RANGE.  Harry C. Zinn, Michael J. Manfredo, Jim Jones, and Linda Sikorowski.

2:15  PROFILE OF MONTANA MOUNTAIN LION HUNTERS.  Rob Brooks.

2:30  COUGAR - HUMAN INTERACTIONS IN BRITISH COLUMBIA.  Daryll Hebert, and Dan Lay.

2:45  HISTORY OF HUMAN INTERACTIONS WITH MOUNTAIN LIONS IN AND AROUND CUYAMACA RANCHO STATE PARK.  Robert Turner.

3:00-3:15  Break

Session Twelve: Incident Analysis and Management Programs
W. Douglas Padley, Santa Clara Valley Water District, Chair
3:15-5:00

3:15  PUBLIC REPORTS OF MOUNTAIN LIONS INCIDENTS IN CALIFORNIA.  Douglas Updike.

3:30  MOUNTAIN LION INCIDENT POLICY AND PROCEDURE.  Douglas W. Ruth, and David V. Holt, Jr.

3:45  EFFECTS AND PATTERNS OF MOUNTAIN LION PREDATION OF LIVESTOCK ON SMALL AND MEDIUM SIZED PROPERTIES IN SANTA CATARINA, BRAZIL.  Marcelo Mazzolli, Catherine Bartlet Ryan, and Mauricio Graipel.

4:00  MOUNTAIN LION-HUMAN AND MOUNTAIN LION-LIVESTOCK INCIDENTS IN MONTANA.  Shawn J. Riley, and Keith E. Aune.

4:15  MOUNTAIN LION DEPREDATION AND HUMAN ACTIVITY IN CALIFORNIA: TESTING SPECULATIONS.  Steven G. Torres, Terry M. Mansfield, and Janet Foley.
4:30 DEVELOPING AN ADAPTIVE MANAGEMENT PROGRAM FOR MOUNTAIN LIONS (*Felis concolor*) IN MONTANA. Shawn J. Riley, and Richard A. Malecki.

4:45-5:00 Concluding remarks: where do we go from here?
RESEARCH REPORTS
The mountain lion, more commonly referred to in Florida as the panther (*Puma concolor coryi*), was first protected by the Florida Game and Fresh Water Fish Commission (FGFWFC) in 1950 by listing it as a game animal. This restricted the taking of it to a special hunting season and halted indiscriminate killing as a "nuisance species". The panther was given complete legal protection in 1958 and attained federal listing as an endangered subspecies on March 11, 1967.

A Florida Panther Recovery Team was formed in July 1976 to develop a recovery plan for the animal, and, in October 1976, FGFWFC began a study to determine if and where there might be a population of panthers that could be managed to prevent their extinction. A population was documented in the Big Cypress region in 1978.

FGFWFC then initiated a study in 1981 using radio-telemetry to determine habitat requirements and other life history information valuable to protection efforts. The following year the panther was declared Florida's official state animal, voted so by the school children of the state. The first Florida Panther Recovery Plan was approved by the U.S. Fish and Wildlife Service in 1982 and was revised and updated in 1987. The Florida Panther Interagency Committee was established in May 1986 to provide a coordinated recovery effort for the Florida panther. This committee is composed of the Southeast Regional Directors of the U.S. Fish and Wildlife Service and the National Park Service, the Executive Director of the FGFWFC, and the Secretary of the Florida Department of Environmental Protection. The Committee provides the overall guidance and direction for the Florida panther recovery program.

**POPULATION STATUS**

The only documented breeding population of Florida panthers occurs in southern Florida from Lake Okeechobee southward, primarily in the Big Cypress and Everglades physiographic regions (Figure 1). The current estimate is that there are 30-50 animals in a range of 4,000+ mi² in this population: hence, the panther may be teetering on the brink of extinction. Computer analysis using information compiled at a Florida Panther Population Viability Analysis Workshop in February 1989 indicated that, without intervention, the Florida panther population had a high probability of becoming extinct in 25 to 40 years.

The Florida panther faces the threat of extinction on 3 fronts. First, there is continual loss of panther habitat through human development. This continuing decline in available habitat reduces the carrying capacity and, therefore, the numbers of panthers that can survive. Second, genetic variation is probably decaying at a rate that is causing inbreeding depression (reduction of viability and fecundity of offspring of breeding pairs that are closely related genetically) and precluding continued adaptive evolution (Seal and Lacy 1989). Third, panther numbers may already be so low that random fluctuations could lead to extinction.

**MANAGEMENT AND RESEARCH**

Protection of remaining habitat (Logan et al. 1994), genetic restoration (Johnson et al. 1995, Seal 1994) and an evaluation of the feasibility of reestablishing additional Florida panther populations (Belden and Hagedorn 1993, Belden and McCown 1996) are ongoing projects.

The Florida Panther Interagency Committee formed a Habitat Preservation Working Group in 1991 to develop a comprehensive plan for habitat preservation. The Florida Panther Habitat Preservation Plan (Logan et al. 1994) identifies occupied and potential panther habitat, threats to these habitats, and the options available to maintain sufficient habitat for a self-sustaining population of panthers in southern Florida. Approximately 53% of occupied panther range occurs on private lands. Through efforts of the FGFWFC and American Farmland Trust, a Landowner Working Group was formed in February 1994. This group allowed private landowners in southern Florida to outline incentives which could be used to carry out panther habitat protection on private lands.

A workshop was convened in September 1994 by the Conservation Breeding Specialist Group of the SSC/IUCN at the request of FGFWFC to assist in the formulation of a plan for the genetic restoration and management of the Florida panther population. "A Plan for Genetic Restoration and
Figure 1. Presently known range of the Florida panther, February 1996.
Management of the Florida Panther (*Felis concolor coryi*) (Seal 1994) was developed at this workshop. Following this plan, 8 young-adult, non-pregnant female mountain lions were captured in Texas between December 1994 and May 1995 and brought to Florida for release into the Florida panther population. These animals were released from March through July 1995 and are presently being monitored along with radio-collared Florida panthers to evaluate the success of genetic restoration. Each of these animals established home ranges generally in their areas of release, one was struck and killed by an automobile in September 1995, and 4 of the remaining 7 females have produced litters.

Five radio-instrumented and sterilized mountain lions from Texas, used as surrogates for Florida panthers, were released in the vicinity of the Osceola National Forest in northern Florida in June 1988. They were monitored for almost a year to determine the feasibility of translocating panthers into northern Florida and southern Georgia (Belden and Hagedorn 1993). Results from this study were used to design and implement a second study in February 1993 to evaluate the use of captive-raised animals in the reestablishment of Florida panthers in northern Florida and southern Georgia. Nineteen mountain lions, including 6 raised in captivity and conditioned for release into the wild, were released into the northern Florida study area and monitored through June 1995 (Belden and McCown 1996). This study found that reestablishment of additional Florida panther populations is biologically feasible. However, complex social issues (fear of the animal, fears concerning depredation on livestock, concerns for property rights, decrease in game to hunt, etc.) were identified that must be satisfactorily resolved, and it must be decided whether the tremendous costs involved (economic, political, social, etc.) in the reestablishment of additional Florida panther populations can be offset by the benefits gained in reducing the risk to the present Florida panther population.

**LITERATURE CITED**


STATUS AND MANAGEMENT OF MOUNTAIN LIONS IN NEVADA

Mike K. Cox. Nevada Division of Wildlife
San Stiver. Nevada Division of Wildlife

Key words: Mountain Lion, *Puma concolor*, Nevada, Status

Abstract  Mountain lions (*Puma concolor*) are found throughout Nevada primarily on mountain ranges that are surrounded by low elevation valleys. Using data from harvested lion numbers, the population trend for mountain lions from 1990-1995 is stable to increasing. The Nevada Division of Wildlife (NDOW) in 1994-1996 developed a comprehensive mountain lion management plan. Over the last five years, there have been less than ten reported cases of lions attacking humans in Nevada. An average of 161 mountain lions were taken by sport hunters from 1993-1995. NDOW encourages research that can be directly applied to management of lion populations.

The mountain lion has been legally classified by the State Board of Wildlife Commissioners as a game animal since 1965. The Nevada Division of Wildlife (NDOW) through their State Board of Wildlife Commission has full responsibility for the management of mountain lions in the state. Since one of the earliest known accounts of lions in Nevada, *Reese River Reveille* newspaper 1864, "Unwelcomed Visitor, California Lion ...", mountain lions have been a dominant and noteworthy predator in the Great Basin Ecosystem. Being a secretive predator, they are rarely observed by most humans. Nevertheless, mountain lions are recognized as having substantial ecological, recreational, educational, and aesthetic value.

POPULATION STATUS

Mountain lions are thought to have established territories on at least 50% of Nevada's 110,000 square miles. This includes primarily island habitats situated on mountain ranges that are surrounded by low elevation valleys. The valley floors are consistently crossed by dispersing mountain lions traveling from one range to the next, but due to prey availability, have limited value as lion habitat. Low density lion populations exist from the extreme southern Mojave Desert mountain ranges to the highest elevation alpine forests in Nevada, with the highest density of lions occurring between 1,820 and 2,575 m. This elevation zone is dominated by pinyon pine (*Pinus spp.*), juniper (*Juniperus spp.*), mountain mahogany (*Cercocarpus* sp.), and various shrub communities where the primary prey species, mule deer (*Odocoileus hemionus*), are most abundant.

Based on best available lion demographic attributes and documented lion harvest since 1970, the estimated 1995 mountain lion population was 3,200 - 4,000 individuals. This estimate represents a regional population including not only Nevada but adjacent lands in bordering states. NDOW has adapted a population model based upon the initial work done by George Keister, of the Oregon Department of Fish and Wildlife. The primary thesis of the model is that a minimum number of lions in each age and sex class must exist to sustain known age and sex harvest in a replicated population using best known reproductive and survival parameters.

Using data from harvested lion numbers, the population trend for mountain lions over the last five-year period is stable to increasing (Fig. 1). The relationship between mountain lions and deer shown in Figure 1 is representative of the overall trends in both predator and prey populations. Though there are unrelated factors such as weather that effect short-term harvest levels. Based on the changes over time by both populations, a reasonable interpretation is that mountain lion abundance responds to or 'tracks' deer abundance with a year or two lag time. This trend appeared to hold well until 1991, when Nevada observed a crash in the deer population. With unit effort by lion hunters holding relative constant, it seems that mountain lion abundance was maintained through opportunistic use of alternative prey species other than mule deer. It remains to be seen, if the lion population can sustain its current numbers until the deer population rebounds.

MANAGEMENT AND RESEARCH

Because of societal changes and increased public awareness, NDOW initiated an internal mountain lion task force in 1994. The task force developed a comprehensive mountain lion management plan for review through a public scoping process and for final approval by the state Wildlife Commission. The plan provides the Division of Wildlife with a structured and rational approach to all aspects of mountain lion management. The first phase of the planning process involved evaluating the agency's role and responsibilities, lion ecology and harvest, lion depredation and public safety concerns, economics, and a host of other issues. A draft plan was prepared with a series of public scoping meetings held in all counties with all interested publics invited to participate and provide input to the plan. After several months of meetings the task force modified the plan based on public
input into the policies and procedures of the plan. The policies are the foundation of the plan that are to guide NDOw in the management of the species. The following include the resulting policy concepts: conservation of the species; control of mountain lions damaging property; control lions threatening human, health, and safety; maintain moderate harvest through lion hunting with the use of hounds; control of lions when they are shown to be a limiting factor to a localized wildlife population; encourage lion research; emphasize public education on mountain lions.

Currently, the management program involves depredation control, sport harvest, and data collection. Under current procedures, a landowner claiming the loss of livestock may contact the Division of Wildlife or the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control (ADC) to investigate and confirm property loss due to mountain lion. If confirmed, ADC or the landowner under a depredation permit, may pursue and kill the offending mountain lion. Most often when a domestic pet is taken by a mountain lion, deterrent methods are suggested to prevent further loss.

In 1994 and 1995 ADC received a total of 149 and 104 calls respectively, regarding lion predation on livestock (C. L. Johnson of ADC, pers. comm.). NDOw received approximately 20 additional calls in 1994 and 28 additional calls in 1995, primarily on lion predation to pets and concerns for human safety. A general trend of increasing depredation complaints on mountain lions occurred from the late 1980's through 1994. In 1995 there was a drop in complaints, especially from the ranching community regarding depredation on livestock. From 1990 to 1995, an average of 47 mountain lions were killed annually in response to depredation, primarily involving livestock.

Periodically, mountain lions are involved in encounters with humans in Nevada. Over the last five years, there have been less than ten reported cases of lions attacking humans in Nevada. Only one case involved a lion making physical contact, where a woman received minor injuries, before the lion was driven away by two men. Due to incomplete records and reporting by the public, no comparison can be made of the number of lion encounters in Nevada through time. To NDOw’s knowledge, the only known human fatality from a lion attack was a young boy back in 1880. Future emphasis will be placed in providing information to the public on how to reduce the risk of having a dangerous encounter with a mountain lion, improve documentation of lion encounters, and provide guidelines to NDOw employees in responding to lion/human encounters.

Currently, mountain lions are harvested in Nevada under a sport harvest objective system, where unlimited tags are sold. The statewide average harvest objective for the last three years (1993-1995) for all management units has been 239 mountain lions. An average of 161 mountain lions were taken by sport hunters during each of the previous three hunting seasons. Hunting seasons typically run from October 1 through April 30. Mountain lion tag holders are responsible for calling a toll-free telephone number during the hunting season to determine whether a particular management unit(s) is open or closed (when the harvest objective was met).

NDOw spends approximately $100,000 annually on the management of mountain lions. Funds are primarily spent by biologists and game wardens during mandatory check-ins of harvested mountain lions and development of federal aid reports. Funding may be pursued to increase educational efforts regarding mountain lion public safety and general ecology. Opportunities to collect additional information on mountain lion demography and hunting pressure may also be assessed. ADC, in the pursuit of depredating mountain lions, expended approximately $41,000 in 1994 and $38,000 in 1995.

Currently, no formal research on mountain lions is being conducted either by the Division of Wildlife or any research organization in Nevada. The most recent research activity involving mountain lions was a study focused on wild horse recruitment in relation to mountain lion predation. The study was located along the border of California and Nevada.

Much of what is known about mountain lions in Nevada is based on a 10-year study that was completed in 1982, "The mountain lion in Nevada", Ashman et al. 1983. NDOw encourages future research that may provide a better understanding of lion demography and predator-prey relationships that can be directly applied to management of lion populations.

LITERATURE CITED

SOURCES AND DISTRIBUTION OF PROPOSITION 117 FUNDS

E. Lee Fitzhugh. Cooperative Extension Specialist, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, CA 95616

Key words: California, Mountain Lion, Economics, Habitat, Taxes, Voter Initiatives, Puma concolor

INTRODUCTION

The "Mountain Lion Initiative" was a nickname for Proposition 117, a voter initiative measure that appeared on the June, 1990 California ballot. Officially, it was called the "California Wildlife Protection Act of 1990." In April, 1990, I wrote a fiscal analysis of Proposition 117 (Fitzhugh 1990a). While never officially published, the analysis was publicly distributed, and is still available. Now, on the eve of another election in which a mountain lion initiative appears, several people have asked about the fiscal results of Proposition 117. This paper, then, is an attempt to document what has actually happened, whereas in 1990, I could only write what was expected. I will review Proposition 117, restate the 1990 predictions, present the actual sources and expenditures since 1990, and tell what has been accomplished with the money.

It is important to emphasize that the initiative on the March 1996 ballot, Proposition 197, will not significantly change Proposition 117's funding and expenditure provisions, which will continue until the fiscal year 2020-21 unless voters change them separately. (Since this was written, Proposition 197 was defeated).

Proposition 117 specified that all agencies receiving funds from Proposition 117 submit an annual report on those expenditures to the Wildlife Conservation Board in the Resources Agency. The proposition did not require that the Wildlife Conservation Board compile the reports, but they have done so (Wildlife Conservation Board 1991, 1992, 1993, 1994). I would like to thank the Resources Agency and W. John Schmidt, executive director of the Wildlife Conservation Board, for making available to me the summaries of these agency reports. Marilyn Cundiff-Gee and Marie Reed gathered and mailed them, and helped me understand how the various figures were derived from the separate agency reports.

METHODS

In December, 1989, I wrote to the agencies that I thought would be impacted by Proposition 117, asking for their assessment of how Proposition 117 might affect their budgets. All agencies contacted responded with information except the Santa Monica Mountains Conservancy and the California Tahoe Conservancy. The Department of Finance provided a listing of the 1990-91 proposed Governor's budget, which would be affected by Proposition 117. This list included a few agencies I had not contacted, but it agreed with responses received from each agency. I summarized this information in an unpublished report (Fitzhugh 1990a). I also analyzed the language of Proposition 117 (Fitzhugh 1990b). Both of these reports provided information on the intent of Proposition 117, as did the accomplishment reports from the Wildlife Conservation Board (1991, 1992, 1993, 1994).

The summary reports prepared annually since 1990-91 from the Wildlife Conservation Board did not directly provide the information I wanted to report in this paper. Instead, I copied data from tables and text into a spreadsheet so I could calculate totals and summary statistics not provided by the Wildlife Conservation Board. Data were not uniformly reported by the various agencies, so there are gaps in some categories. Projects on streams and trails were reported in linear measure, and I assumed a 100-yard width figure in order to calculate acreages for those projects. Some reports did not clearly separate acres purchased, improved, or studied. In those cases, I used the context and the descriptive name of the project to assign the acreages to a category. In some cases, acreages were not reported. This occurred mostly for projects that were only studies of areas, or for projects in which funds were given to the Department of Fish and Game for stream restoration. The effect of these omissions will bias those categories downwards, but the bias is believed to be relatively minor.

The Wildlife Conservation Board also provided a copy of a spreadsheet report that listed the sources of funds for transfer to the Habitat Conservation Fund (Proposition 117), and the amounts transferred from 1991 through 1996 (Wildlife Conservation Board 1996).

Review of Proposition 117

Proposition 117 was a California voter initiative passed in June, 1990. The bulk of the initiative related to fiscal matters, but there were some important non-fiscal provisions. Briefly, Proposition 117 permanently prohibited sport hunting for mountain lions (§ 4800). It also revised conditions under which mountain lions could be taken as a result of depredation, and methods that could be used (§ 4801-4809), making them more restrictive than previously. Proposition 117 cannot be amended by the legislature except by a 4/5 vote.

No new revenues were created by Proposition 117, but it redirected $30,000,000 each year for 30 years ($900,000,000) to its own purposes. Provisions allowed future bond issues to be counted toward satisfying Proposition...
117. Also, some existing funds already used for purposes compatible with Proposition 117 could be counted toward fulfilling Proposition 117 requirements, but there were limits on the extent to which this substitution could be done (§ 2796(a)5,6). In later tables I will call this substitution "overlap." The legislature could, at their discretion, use general funds to satisfy most of the requirements, but there were limitations on this use, also.

The proposition specified that the Controller shall transfer 10 percent annually from the Unallocated Account in the Cigarette and Tobacco Products Surcharge Fund (Tobacco Tax, Proposition 99) for use according to Proposition 117 (§ 2795(a)). It also specified that no additional allocation from that account shall be made for any natural resource or environmental program (§ 2795(b)). In the 1990-91 Governor's proposed budget, 10 percent of the Unallocated Account in the Tobacco Tax fund would have been about $18,000,000 (personal communication, Don Rascon, Department of Finance, April 9, 1990).

No other accounts were required to supply funds to Proposition 117, but several others were mentioned as possible sources of funds. These were: 1) Public Resources Account in the Tobacco Tax Fund; 2) the California Environmental License Plate Fund; 3) the Endangered and Rare Fish, Wildlife, and Plant Species Conservation and Enhancement Account in the Fish and Game Preservation Fund; 4) the Wildlife Restoration Fund; 5) the General Fund.

Proposition 117 placed restrictions on the use of funds from some accounts. 1) Funds from the Public Resources Account of the Tobacco Tax Fund were authorized only to the extent authorized by the Tobacco Tax and Health Protection Act of 1988 (§ 2796(a)1); 2) Except for the Endangered and Rare... Account of the Fish and Game Preservation Fund mentioned above, other expenditures from the Fish and Game Preservation Fund could not be accounted as expenditures for Proposition 117 (§ 2796(b)); 3) Transfers of federal, local, or private funds, or transfers from the State Coastal Conservancy Fund pursuant to § 31011 of the Public Resources Code could not be accounted toward Proposition 117 funds. These restrictions prevent many of the Department of Fish and Game and State Coastal Conservancy funds from contributing.

Except for withdrawals from the Unallocated Account of the Tobacco Tax, the sources of funds for Proposition 117 were left to a process of negotiation each year between agency representatives and legislators. In 1990, I presumed that both agencies and legislators would try to find as many "compatible" expenditures as possible, so as to impact the budget as little as possible. Beyond that, political and fiscal expediency would govern, and it was not possible to predict how much would come from which funds.

I have included below a list of agencies scheduled in 1990 to receive money from the accounts targeted by Proposition 117 or that may have lost money to Proposition 117 (Tables 1-3). Some agencies get funds from accounts according to bond issue specifications or laws requiring the allocation. These funds would not have been affected by Proposition 117, and are not included below. The tabulation includes the name of the agency, the amount of potential annual income from Proposition 117, and the proposed 1990-91 budget as provided by the Finance Department. The proposed budget represents the amount of agency budget potentially at-risk for redistribution by Proposition 117. Finally, the last column includes the agency's opinion as to the amount of their budget that would qualify for Proposition 117 goals without redistribution. This represents the amount that could be counted toward Proposition 117 without redistribution of funds.

In interpreting the information in these lists it is important to remember that Proposition 117 would require only $30,000,000 annually, less the amount (about $18,000,000) from the Unallocated Account of the Tobacco Tax, resulting in a potential impact of about $12,000,000 on the "at-risk" budget items. At the discretion of the legislature, General Fund money could be used instead of these special funds, except the Unallocated Account of the Tobacco Tax. Also, if the legislature or the people desire to qualify a bond issue for a future election, the bond issue could substitute for these special funds, with the exception of the Unallocated Account of the Tobacco Tax.

I had no comprehensive list of projects funded by the Tobacco Tax Funds. However, the Department of Fish and Game receives funds from the Public Resources Account that would be at-risk from Proposition 117. As one example, part of the Central Valley Habitat Joint Venture Program of the North American Waterfowl Plan was funded in 1989-90 from the Public Resources Account of the Tobacco Tax Fund.

Actual Sources and Expenditures

The Unallocated Account, Tobacco Tax, supplied $77,773,000 during the past six years (Wildlife Conservation Board 1996), or an average of $12,962,167 per year. This is almost $5,000 per year less than estimated in 1990. The difference may be attributed to declining revenues from the excise tax on tobacco products. The Public Resources

1990 Predictions of Fiscal Impact
Table 1. Funds at risk in the Tobacco Tax Unallocated Account

<table>
<thead>
<tr>
<th>Agency or Department</th>
<th>Proposition 117¹</th>
<th>Budget²</th>
<th>Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Services</td>
<td>0</td>
<td>1,292,000</td>
<td>0</td>
</tr>
<tr>
<td>Mental Health</td>
<td>0</td>
<td>10,000,000</td>
<td>0</td>
</tr>
<tr>
<td>Health Services CHIP³</td>
<td>0</td>
<td>21,741,000</td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Annual amount specified in Proposition 117. Not included is $10,000,000 for the Santa Monica Mountains Conservancy until July 1, 1995, after which the money reverts to the Wildlife Conservation Board.

² From the 1990-1991 governor's proposed budget. $142,048 of this account is earmarked by AB 75 and about $4,000 is for a reserve account. These funds are part of the total Unallocated Account, but cannot be used for Proposition 117.

³ CHIP stands for California Health Care for Indigents Program.

Table 2. Funds at risk in the Tobacco Tax Public Resources Account.

<table>
<thead>
<tr>
<th>Agency or Department</th>
<th>Proposition 117</th>
<th>Budget¹</th>
<th>Potential Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife Conservation Board</td>
<td>12,000,000</td>
<td>1,558,000</td>
<td>Some</td>
</tr>
<tr>
<td>Fish and Game</td>
<td>0</td>
<td>8,313,000</td>
<td>Unknown, severe restrictions</td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>4,500,000</td>
<td>13,418,000</td>
<td>1,000,000 complementary priority, 3,500,000 inequitable</td>
</tr>
<tr>
<td>Boating and Waterways</td>
<td>0</td>
<td>1,000,000</td>
<td>No response</td>
</tr>
<tr>
<td>Forestry and Fire Protection</td>
<td>0</td>
<td>3,176,000</td>
<td>No overlap</td>
</tr>
<tr>
<td>Water Resources</td>
<td>0</td>
<td>250,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>California Tahoe Conservancy</td>
<td>500,000</td>
<td>1,500,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Water Resources Control Board</td>
<td>0</td>
<td>764,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>California Conservation Corps</td>
<td>0</td>
<td>213,000</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

¹ From the 1990-91 governor's proposed budget.

Account of the Tobacco Tax supplied $24,411,000, so that the Tobacco Tax (Proposition 99) altogether provided 57 percent of the funds for proposition 117. This is more than $102 million dollars from 1990 through 1996. Figure 1 shows the five largest contributors. The smallest of these contributed more than $11,000,000. Table 4 identifies the abbreviations used in the figures and other tables and the amounts and proportions each one provided to Proposition 117. Smaller contributions came from 12 other funds (Figure 2) whose cumulative total was almost $29,000,000. Proposition 70, the Wildlife Coastal, and Park Land Conservation Bond of 1988 provided more than 30% of the $29 million supplied by the minor contributing funds. These Proposition 70 allocations came from the Department of Fish and Game fund and the State Coastal Conservancy fund. Four other funds provided about the same amount as either one of the Proposition 70 funds. They were the Fish and Wildlife Habitat Enhancement Bond of 1984, the Energy Resources Programs Account, the Environmental Enhancement and Mitigation Demonstration Program, and the Outer Continental Shelf Land Act Revolving Fund.

Who Gets the Money?

Each year, Proposition 117 appropriates $4,500,000 to the Department of Parks and Recreation, of which $2,000,000 is for 50 percent matching grants to local agencies and for purchasing wildlife corridors and urban trails, for nature interpretative programs, and other programs designed to bring urban residents into park and
Table 3. Funds at risk in the Environmental License Plate Account.

<table>
<thead>
<tr>
<th>Agency or Department</th>
<th>Proposition 117</th>
<th>Budget(^1)</th>
<th>Potential Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources (Tahoe Planning)</td>
<td>0</td>
<td>75,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Special Resources Program</td>
<td>0</td>
<td>665,000</td>
<td>No Overlap</td>
</tr>
<tr>
<td>California Tahoe Conservancy</td>
<td>See Table 2</td>
<td>1,826,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Air Resources Board</td>
<td>0</td>
<td>1,104,000</td>
<td>No Overlap</td>
</tr>
<tr>
<td>Colorado River Board</td>
<td>0</td>
<td>8,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Forestry and Fire Protection</td>
<td>0</td>
<td>4,289,000</td>
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</tr>
<tr>
<td>Fish and Game</td>
<td>0</td>
<td>16,685,000</td>
<td>See Table 2, Text</td>
</tr>
<tr>
<td>Wildlife Conservation Board</td>
<td>See Table 2</td>
<td>0</td>
<td>Some</td>
</tr>
<tr>
<td>California Coastal Commission</td>
<td>0</td>
<td>442,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>State Coastal Conservancy</td>
<td>4,000,000</td>
<td>0</td>
<td>Complete Overlap</td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>See Table 2</td>
<td>490,000</td>
<td>See Table 2, Text</td>
</tr>
<tr>
<td>Water Resources</td>
<td>0</td>
<td>2,736,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>Education</td>
<td>0</td>
<td>515,000</td>
<td>No Overlap</td>
</tr>
<tr>
<td>Food and Agriculture</td>
<td>0</td>
<td>156,000</td>
<td>No Overlap</td>
</tr>
<tr>
<td>General Fund Credits</td>
<td>0</td>
<td>25,000</td>
<td>No Overlap</td>
</tr>
</tbody>
</table>

\(^1\) From the governor's 1990-1991 budget.

wildlife areas. The California Coastal Conservancy is to get $4,000,000, the California Tahoe Conservancy $500,000, and the Wildlife Conservation Board $11,000,000. From 1990-1991 through July 1, 1995, the Santa Monica Mountains Conservancy was to get $10,000,000 per year. After July 1, 1995, this allocation terminated and reverted to the Wildlife Conservation Board.

Agencies may spend these funds to acquire habitat for deer, mountain lions, or rare, endangered, threatened, or fully protected species. They may acquire Significant Natural Areas, acquire, enhance, or restore wetlands, riparian areas, or aquatic habitats for spawning or rearing anadromous salmonids and trout.

Over a 2-year period, one-third of the money should be spent to acquire deer and mountain lion habitat, and the other two-thirds to acquire habitat for listed or protected species. Over the same period, $6,000,000 should be spent on wetlands and the same amount on aquatic and riparian areas. In addition, half of the total should be spent in northern California (north of the Tehachapi Mountains) and half in southern California.

What Has Been Accomplished?

In the first four years, Proposition 117 funds purchased about 195,467\(^2\) acres for the state. It provided studies, assessments, and plans for 1,178,131 acres. Improvements actually have been done on 51,218 acres (Figure 3). These are approximate figures because agencies often mixed planning and enhancement or purchase in the same reporting figure. Also, some agencies did not report acreages of land studied or enhanced, although they had large acreages of those kinds of projects. The acres reported for planning and improvement are inflated because they include work done with funds other than those from Proposition 117. The kinds of habitats purchased, studied,
Table 4. Abbreviations for source funds, amounts and proportions contributed to Proposition 117 for years 1990-1991 through 1995-1996.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Name of Fund</th>
<th>Contribution $</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>P99</td>
<td>Unallocated Account, Tobacco Tax</td>
<td>77,773,000</td>
<td>43</td>
</tr>
<tr>
<td>ELPF</td>
<td>Environmental License Plate Fund</td>
<td>25,711,000</td>
<td>14</td>
</tr>
<tr>
<td>PRA</td>
<td>Public Resources Account, Tobacco Tax</td>
<td>24,411,000</td>
<td>14</td>
</tr>
<tr>
<td>WNACF</td>
<td>Wildlife &amp; Natural Areas Conservation Bond</td>
<td>11,700,000</td>
<td>5</td>
</tr>
<tr>
<td>P70-WCB</td>
<td>Wildlife Coastal &amp; Park Bond Fund of 1988, WCB Account</td>
<td>11,116,000</td>
<td>6</td>
</tr>
<tr>
<td>P70-DFG</td>
<td>Wildlife Coastal &amp; Park Bond Fund of 1988, DFG Account</td>
<td>5,260,000</td>
<td>3</td>
</tr>
<tr>
<td>EEMP</td>
<td>Environmental Enhancement &amp; Mitigation Demo Program</td>
<td>5,000,000</td>
<td>3</td>
</tr>
<tr>
<td>ERPA</td>
<td>Energy Resources Programs Account</td>
<td>4,791,000</td>
<td>3</td>
</tr>
<tr>
<td>P70-SCC</td>
<td>Wildlife Coastal &amp; Park Bond Fund of 1988, SCC Account</td>
<td>3,800,000</td>
<td>2</td>
</tr>
<tr>
<td>FWEHF</td>
<td>Fish &amp; Wildlife Habitat Enhancement Bond Fund of 1984</td>
<td>3,650,000</td>
<td>2</td>
</tr>
<tr>
<td>OCSLARF</td>
<td>Outer Continental Shelf Land Act Revolving Fund</td>
<td>2,969,000</td>
<td>2</td>
</tr>
<tr>
<td>H&amp;WCRF</td>
<td>Harbors &amp; Watercraft Revolving Fund</td>
<td>1,500,000</td>
<td>1</td>
</tr>
<tr>
<td>DFPF</td>
<td>Delta Flood Protection Fund</td>
<td>800,000</td>
<td>0.4</td>
</tr>
<tr>
<td>EEF</td>
<td>Environmental Enhancement Fund</td>
<td>700,000</td>
<td>0.4</td>
</tr>
<tr>
<td>WHCA</td>
<td>Waterfowl Habitat Preservation Acct, Fish &amp; Game Preservation Fund</td>
<td>200,000</td>
<td>0.3</td>
</tr>
<tr>
<td>SCCF</td>
<td>State Coastal Conservancy Fund</td>
<td>100,000</td>
<td>0.1</td>
</tr>
<tr>
<td>FRIF</td>
<td>Forest Resources Improvement Fund</td>
<td>84,000</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 1. Percentages of $179,565,000 during 6 years.

Figure 2. Includes all funds except 5 largest. Percentages of #28,854,000 during 6 years.
What Has Been Done with the Money?

Urban trails and rare or protected species habitat have received the most money from Proposition 117 -- 24 percent each, or $45-$46 million each in the four years from 1991-1994 (Figure 5). Other categories received from $5 million to $23 million over the same four years, from 3 percent to 12 percent of the total. These figures include money spent to improve areas, as well as to buy land or easements. The figures add to $69,000,000 more than the amount provided by Proposition 117. This difference reflects funds from sources other than Proposition 117 that were not separable in the reports received.

I was able to discover the proportions of acres purchased or “protected” in different habitats (Figure 4), but was unable to get the same figures for acres enhanced or studied. The relationships among acreages purchased, enhanced, and studied are shown in Figure 3. The urban trail and rare or protected species habitat categories that were so prominent in money spent are much less so in acreage purchased (Figure 3). This may be caused by differential land prices and/or land improvements as opposed to purchases. Other categories that also lost about half their proportion as compared to the amount of money spent were habitat links and deer-lion habitat. Wetland habitat expanded the proportion from 12 percent of money spent to almost 40 percent of land purchased. Riparian habitat also doubled its proportion.

How Much Real Change Occurred?

I was unable to discover how much of the expenditures were redirections and how much were simply accounting shifts (overlap). For example, overlap would occur if an agency planned and budgeted to buy a piece of land, and did it for its own purposes, then that purchase might be accounted toward fulfillment of Proposition 117 if it also met Proposition 117 criteria. In other cases, such accounting shifts would not be possible, and funds would have to be
redirected from one use to another. Proposition 117 restricts the Department of Fish and Game from some kinds of accounting credits, but in most cases, funds used by other agencies can be credited to Proposition 117.

What Has Been Done for Mountain Lions?

Proposition 117 does not provide much emphasis for buying or improving mountain lion habitat. However, in view of significant popular misconception on this point, it is of value to document just what Proposition 117 has done to preserve mountain lion habitat. To do this, I used the most dense estimate I could find of mountain lion populations. That came from the North Kings Deer Herd study in the Sierra Nevada Mountains near Fresno, California (Neal, Steger, and Bertram, 1987). Don Neal, George Steger, and Ronald Bertram documented a radio-collared mountain lion density of 7.8 adults per 100 square miles. In the four years between 1991 and 1995 Proposition 117 has resulted in the purchase of 14,940 acres, or 23.3 square miles, of deer and mountain lion habitat. A simple formula, 23.3 divided by 100, times 7.8, tells us that Proposition 117 has bought or improved enough land to support 1.8 adult mountain lions in the 4 years of reporting. This land and improvement cost $21,107,000, or more than $1400 per acre.

CONCLUSIONS

Proposition 117 banned the hunting of mountain lions and diverted considerable funds from human health and wildlife management functions to purchase parks, urban trails and habitat for a diverse array of wildlife. The various agencies seem to be having difficulty preparing management plans that are required by Proposition 117, and the proportional allocations of funds are not always exact (Wildlife Conservation Board 1994). However, the intent of Proposition 117 is being accomplished in the administration of the funds. Future distribution of the expenditures may change slightly from what has occurred because the portion formerly provided to the Santa Monica Mountains Conservancy terminated in 1995, and those funds will now be used by the Wildlife Conservation Board. Without voter intervention, Proposition 117 will provide $720,000,000 between 1997-2021 for land purchase and management in urban and rural areas. The activities to be funded by Proposition 117 will come mostly at the expense of other wildlife programs and social and health-related programs.

This fiscal situation will continue to the year 2021 unless voters: 1) pass an initiative to change the fiscal provisions of Proposition 117 or 2) pass one or more bond issues either to relieve the depleted funds or to provide more direct funds for Proposition 117.

LITERATURE CITED


1According to a tabulation based on Table 1 of the Wildlife Conservation Board (1991-1994) reports. My own tabulation of the numbers contained in the individual agency report sections of the Wildlife Conservation Board (1991-1994) reports showed 114,403 acres purchased, as represented in Figure 3.
PUMA BEHAVIORS DURING ENCOUNTERS WITH HUMANS
AND APPROPRIATE HUMAN RESPONSES

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Key words: Mountain Lion, Puma concolor, Human Interactions

INTRODUCTION

Pumas (Puma concolor) attacked and injured nine people in eight incidents in California since 1985 (plus one fatality not confirmed as a puma attack). In the previous 96 years, three people were attacked in two incidents. Five of the 12 people died as a result of the attacks. Possibly lowering the recent attack rate, 10 pumas were killed in 1994 to protect public safety. It is likely that many non-fatal attacks were not reported during earlier years (Beier, 1991). Even so, the increase to known incidents per year from two incidents in 96 years to eight in 10 years is dramatic. If we consider only fatal attacks, the difference is nearly as great. There were three fatalities up to 1986, two of them from one attack in which the people died of rabies or a similar infection. From 1986 through 1995 there were two fatal attacks. Even considering the faults in the data, the difference is too great to be accidental.

A concurrent increase in attacks has occurred throughout the western United States and Canada, along with a large increase in reports of close encounters between humans and pumas. The phenomenon is obviously not an aberration. At the same time, even the current rate of attacks makes them rare, definitely not a "major public safety concern" if numbers are an appropriate measure. However, something about even a small chance of being eaten by a large carnivore wrests the human imagination away from the logic of numbers. Perhaps a measure of quality should temper our numerical estimates of public safety issues.

Agencies and others have supplied instructions regarding what people should do to protect themselves during close encounters with pumas. The foundation for these instructions, and an elaboration on suggested human responses is presented here in the context of 7 different puma behaviors. The principles involved are: 1) most puma attacks on humans seem to have been predatory in nature; 2) cats in general are threatened and intimidated by large, strange, objects approaching rapidly and from above; 3) cats are stimulated to attack by smaller objects moving rapidly across or away from their line of travel. Several attacks on humans, both in captive situations and in the wild, have been stopped when the victim fought back. We know of no instance anywhere in which an attack, once contact was made, was stopped when the victim feigned death. We cannot emphasize too strongly that these descriptions and statements are tentative and hypothetical in nature. They have some basis in research and experience, but that is strictly limited and non-comprehensive. The opinions are subject to error. We hope they will provide a framework to identify research needs so that someday we may be better able to provide guidance to people who may encounter a puma close-up. In the meantime, this is the best we can do.

BASIS FOR THE SUGGESTIONS

Research and observations used in developing Table 1 were primarily from Leyhausen (1979), with significant inputs from Beier (1991), Bogue and Ferrari (1978), Bogue (n.d.), Bogue (pers. comm.), and Fromhold (n.d.). Other information was gleaned from discussions with many biologists who work with or have had experience with puma throughout the country, and with people who work in the field with puma-human encounters.

PUMA BEHAVIORS AND SUGGESTED HUMAN RESPONSES

Based on Leyhausen's (1979) work, and by examining many accounts of attacks on humans by puma during Fitzhugh's original work in that area (Fitzhugh and Gorenzel 1986), and the following expansion of that work by Beier (1991), we conclude that most of the unprovoked attacks by puma have been predatory in nature. We have, therefore, limited the behaviors in the table to predatory behaviors. Any person purposely placing themselves close to a puma should anticipate an attack.

Table 1 contains our best assessment of puma behaviors associated with human/puma encounters in the puma's predatory mode. We have included an interpretation of human risk associated with each behavior and our best prediction of an appropriate human response to the described puma behavior.

This material deals with encounters before physical contact occurs. Some attacks are so secretive that the person
may not be aware of the puma until the attack has occurred. The element of surprise lies with the puma in that case. The person can do nothing more than fight back the best way the situation allows. In some cases, fighting back has thwarted puma attacks.

Some basic principles of cat behavior are worth restating. Cats, including puma, are intimidated by anything unusual that is larger, especially taller, than themselves, and by things that approach rapidly. Positions above a cat are positions of dominance, and those below are positions of subordinance. Prey that fight back sometimes cause the cat to end the attack. According to Leyhausen (1979), the drive for prey-catching must vent itself, but substitute objects will suffice. Beier (1991) reported an incident in which a boy was saved when an attacking puma vented its effort on a dropped shoe. Perhaps rolling a small backpack or other item of equipment across the puma’s field of vision might distract it

<table>
<thead>
<tr>
<th>Puma Activity</th>
<th>Meaning</th>
<th>Human Risk</th>
<th>Appropriate Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puma far away and moving away</td>
<td>Secretive and avoidance</td>
<td>Insignificant</td>
<td>Keep children where they can be observed.</td>
</tr>
<tr>
<td>Puma &gt; 100 yards away, various positions and movements, attention directed away from people</td>
<td>Indifference</td>
<td>Slight, provided human response is appropriate</td>
<td>Avoid rapid movements, running, loud, excited talk. Stay in groups; keep children with adults. Observe puma. For agencies, this may indicate future problems if repeated.</td>
</tr>
<tr>
<td>Puma &gt; 50 yards away; various body positions; ears up; may be changing positions; intent attention toward people; following behavior</td>
<td>Curiosity</td>
<td>Slight for adults given proper response. Serious for unaccompanied children</td>
<td>Hold small children; keep older children close to an adult. Do not turn back on puma; assume standing position on ground, rocks, or large equipment that are above puma if possible. Look for sticks, rocks, or other weapons and pick them up, using an aggressive posture while doing so. Watch puma at all times. However, if puma sits, looks away, and grooms itself, this is not a predatory situation, and you should imitate the puma, but keep it in peripheral vision. For agencies, consider warning visitors and limiting hiking to groups.</td>
</tr>
<tr>
<td>Puma &lt; 50 yards away; intense staring at humans; hiding</td>
<td>Assessing success of attack</td>
<td>Substantial</td>
<td>All of above steps, plus place older children behind adults. If a safer location or one above the puma is available, go there. Do not run. Raise hands and other objects such as jackets above head so as to present image of bulk as high as possible. Prepare to defend yourself.</td>
</tr>
<tr>
<td>Intense staring and hiding coupled with crouching and/or creeping toward humans</td>
<td>Moving to attack position</td>
<td>Serious if within 200 yards</td>
<td>Take all the above actions. If possible, move slowly to place large objects such as trees, boulders between yourself and the puma, but do not lose sight of the puma. Smile! (Show your teeth). Make menacing sounds; throw things if puma is close enough to hit.</td>
</tr>
<tr>
<td>Crouching; tail twitching; intense staring at humans; ears erect; body low to ground; head may be up</td>
<td>Pre-attack; awaiting opportunity</td>
<td>Grave</td>
<td>Do all of the above and use whatever weapons you have. If you have lethal weapons take careful aim and use them now. Pepper spray may be effective if puma is close enough and downwind. If you have rocks or other items that can be thrown, do so.</td>
</tr>
<tr>
<td>Ears turned so the &quot;fur&quot; side is forward; tail twitching; body and head low to ground; rear legs may be &quot;pumping&quot; or &quot;treading&quot; gently up and down.</td>
<td>Imminent attack; puma is ready to leap</td>
<td>Extreme</td>
<td>Prepare to defend yourself in close combat. Fight back. Make menacing noises. The attack may happen within seconds. If you have any chance of averting it, it is by acting aggressively toward the puma. If the distance is too great to use a stick, run rapidly toward the puma until you can put the stick in its face and eyes. If you lack a stick, run toward the puma with arms high, making loud noises. Stop before you are within striking distance of its paws. Rapid movements towards the puma, especially from above it, may still deter an attack. Avoid positions below the puma; do not turn your back on it.</td>
</tr>
</tbody>
</table>
long enough for the person to take some other needed action, such as break off a limb or pick up rocks. Please note that when you bend down to pick up weapons, do so facing directly at the puma; bare your teeth, and make threatening noises. Growling and barking like a dog would be appropriate. Your object is to appear to be a predator about ready to spring. In all close contacts with puma, you must try to appear as the top, dominant predator.

Prey-sized items that move rapidly across the cat's field of vision, or at an angle, stimulate prey-catching behavior. If an encounter is not predatory, but is, or turns into, a defensive or threat encounter for the puma, it is possible the puma may sit and look away or groom itself. This behavior is to communicate that the puma does not intend to attack. If the person behaves similarly, the puma may break off the encounter and leave because it feels less threatened. We would, however, always keep the lion within our peripheral vision. If you see that the puma has recently killed an animal nearby, slowly withdraw from the area, while watching the puma, without turning your back on it.

The showing of teeth, which people interpret as smiling, is often a threat display to the animal. Thus, Davy Crockett truly may once have "grinned down" a bear. We know of no research or observation that supports "grinning down" any dangerous animal, but once a puma attack is imminent, the human victim needs all the threatening display he/she can muster. Grinning, or showing your teeth, won't hurt, at that stage, if you can do it. It may also keep you from panic. Aggressive shouts or other loud sounds also may be helpful (Beier 1991). Lastly, we want to emphasize that puma, like other cats, are highly individualistic. Some are more aggressive than others. There are no guarantees that anything will work, or that something that worked once will work again. Good Luck!

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THE POTENTIAL FOR CATASTROPHIC INFECTIOUS DISEASE OUTBREAKS IN POPULATIONS OF MOUNTAIN LIONS IN THE WESTERN UNITED STATES.

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Key words: Mountain Lion, Infectious Disease, Catastrophe

INTRODUCTION

Populations of mountain lions (Puma concolor) exist throughout the western United States, constituting a valuable biological resource. Successful management of these populations requires proactive steps to anticipate and hopefully deter events that might adversely affect mountain lions. In general, there are 3 types of unpredictable adverse impacts upon any population: demographic stochasticity, genetic impoverishment, and environmental stochasticity (Shaffer 1981). Particularly severe adverse events are catastrophes, such as severe environmental stresses, and disease. This paper considers the population ecology of several important infectious diseases, which might, under particular conditions, lead to pronounced reduction of mountain lion populations. Such consideration is particularly pressing given recent suggestions that Florida panthers (P. c. coryi) and African lions (Panthera leo) may be suffering high fatality rates due to infectious diseases (Roelke et al. 1993, Morell 1994). A brief overview of western mountain lion populations structure will be followed by a summary of six of the likeliest disease candidates for major mountain lion population catastrophes.

Disease in a population is a product of 2 factors: competence of the disease agent to adversely affect the host population, and vulnerability of the host population. Likely characteristics of a potential regulating agent include high rates of infectivity and lethality or capacity to reduce host fecundity. Host vulnerability typically reflects population size, sometimes associated genetic impoverishment, and perhaps high densities allowing for high rates of disease transmission. We can think of host populations along a spectrum of structure, from very small, discrete populations, to large groups of individuals that freely interact with other groups, so that it becomes difficult to even identify a population per se. Reintroduction of some diseases (i.e. those which produce immunity in recovered hosts) is associated with lower mortality rates or even failure to establish an epidemic, compared with the primary disease introduction in that population. Susceptibility to infectious diseases may be enhanced in populations that have lower genetic variability (O'Brien and Evermann 1988). Thus longevity of immune response, numbers of immune hosts (herd immunity), and whether or not disease remains endemic within the population or is repeatedly introduced from outside the population all contribute to the risk that a given agent might regulate or even wipe out a host population. The role of infectious diseases in host population regulation and/or endangerment varies among hosts and diseases. An excellent review of approaches to these problems is McCallum and Dobson (1995). Diseases have been observed to reduce and induce host population fluctuations, cause gradual, consistent reduction in population sizes, or lead to single time-point large scale population reduction. For example, Trichostrongylus tenuis may lead to population fluctuations in its host, the red grouse (Lagopus lagopus) (Dobson and Hudson 1992). An alternative interpretation is behavioral (Mountford et al. 1990). Examples of diseases that contribute to population endangerment or extinction include canine distemper in black-footed ferrets (Mustela nigripes) (Williams and Thorne 1996), and rabies in the European wolf (Canis lupus) (Sillero-Zubiri et al. 1996). Population oscillations due to disease have been described for Florida bobcats (Wassner et al. 1988), but not apparently for panthers (Maehr and Caddick 1995). Single time-point crashes have been observed in African lions due to canine distemper and feral cats (Felis catus) due to feline panleucopenia.

Mountain lion populations vary in their structure and vulnerability to catastrophic disease outbreaks. Florida panthers are considered by some to be especially vulnerable to disease, due to their small, discrete populations, with 50 individuals (Roelke et al. 1993). A corresponding low level of genetic variability may be reflected in reduced fitness (see Hedrick 1995, Maehr and Caddick 1995). Western lion populations vary from relatively small, isolated populations (as in parts of southern California (Beier 1993) and possibly Nevada mountain ranges (Ashman 1976)), to "populations" consisting of adult lions scattered across home ranges intermixed with mobile subadults. Individuals may migrate over dozens to hundreds of kilometers if there is suitable, contiguous habitat available.

Interestingly, Maehr and Caddick (1995) document a very high intrinsic rate of growth ($r$) for Florida panthers, typical also of domestic cats at low initial population size. Foley et al. (1996) show that overall $r$ in California exceeded 0.1 over the last 20 years. The effect of high $r$ could be to produce waves of disease-naive, juveniles, increasing the impact of some diseases over what would be anticipated in a population with a stable age distribution and "regular" cycles of disease.
Finally, host populations are vulnerable only if they are exposed to disease, due to individual movement into infected areas, exposure to vectors, and interaction with alternate hosts of the disease. For many diseases, feral cats represent a significant alternate host to mountain lions, and we might therefore anticipate increased rates of infection due to some of these pathogens in semi-urban populations, such as parts of southern California. Below, 6 infectious disease agents are reviewed, with descriptions of basic biology, clinical presentation and testing interpretations, and potential impact on western mountain lion populations.

RABIES

Rabies is a fatal, viral infection of all mammals which has strains that are adapted to certain hosts in certain geographical locations. Western foci of rabies currently exist in striped skunk (Mephitis mephitis) in California and Texas, gray foxes (Urocyon cinereoargenteus) in Arizona and Texas, and coyotes (Canis latrans) in Texas (Krebs et al. 1995). Each year, individuals of numerous other species are incidentally infected with rabies, including opossums (Didelphis virginianus), raccoons (Procyon lotor), rodents, deer (Odocoileus hemionus), bobcats, cats and dogs (Canis domesticus), and in 1994, a single mountain lion near Covelo, California. Disease progression occurs differently in different species, with some reports suggesting a more chronic, "atypical" disease course in skunks and bats, compared with dogs. Chronic and/or latent infections, sometimes with the infected animal shedding infectious virus, have been described for cats and striped skunks (Perl et al. 1977, Murphy et al. 1980). Infection can occur when an animal is bitten by an infected animal, transplacentally in some species, and by ingestion of infected meat (Fischman and Ward 1968).

Testing for rabies infection is less straight-forward than for some of the other diseases discussed here, because classical diagnosis requires pathological visualization of brain tissue. The traditional test is documentation of Negri bodies, which are cytoplasmic inclusion bodies consisting of aggregates of internally budding membrane bound virus particles. More modern testing procedures include immunofluorescent antibody (IFA) on brain tissue, DNA-based polymerase chain reaction (PCR) tests, and mouse and mouse cell line inoculation.

Compiling reports of rabies cases and seroprevalence assays into an accurate picture of rabies risk to mountain lions is an extremely difficult task. There is significant evidence that most infections in other wildlife and domestic species due to chance, sporadic contact with the major host species in that geographical region (i.e. striped skunks in California and coyotes in southern Texas) (Krebs et al. 1995). The 2 likely explanations for this phenomenon are ecological isolation among species and virus strain-host species evolutionary adaptations (Smith 1989). It is unreasonable to assume significant ecological isolation between mountain lions and most medium mammal species, because lions efficiently prey upon many available species. However, earlier data showed that rabies virus strains that were adapted to foxes were distinctly less pathogenic to skunks, and that experimentally inoculated foxes shed amounts of virus in their saliva which would often be sufficient to effectively create an infection in a skunk (Smith 1989). If a large number of skunks eventually acquired a fox rabies strain in an area with endemic fox rabies, those skunks might excrete higher salivary viral loads and create a secondary skunk rabies cycle, a prediction consistent with observed patterns. Another example of distinct host species-rabies cycles is gray fox and skunk rabies in Arizona and Texas, where monoclonal antibody analysis of the N protein revealed clear distinctions between the virus strains associated with the major host species.

The implication of these findings for potential rabies in mountain lions is that we might anticipate one of two possible patterns: sporadic cases in mountain lions often due to interaction with infected major host species, or the unlikely possibility of a lion-specific cycle developing within the primary host-species cycles. The biology of skunk, fox, and coyote rabies strains when inoculated into mountain lions has not been explored, but the worst-case scenario for mountain lion-adapted rabies would be if lions developed high salivary viral loads after inoculation, and had frequent exposure to the primary host species. Additionally, rabies in domestic cats might be efficiently spread to mountain lion predators.

CANINE DISTEMPER

Until recently, canine distemper virus (CDV) was rarely associated with disease in cats. Isolated incidences of canine distemper were reported for captive snow leopards (Panthera uncia) already affected by panleucopenia (Fix et al. 1989), and a captive Bengal tiger (Panthera tigris) (Blythe et al. 1983). In 1994, a report appeared in "Science" documenting a fatal epidemic of canine distemper in African lions in the Serengeti (Morell 1994). The total mortality loss due to CDV in Masai Mara lions approached 30% (Roelke-Parker et al. 1996). In Kenya, canine distemper has been described in feral dogs with seroprevalence at one time point of 76% (Alexander and Appel 1994). In the United State, distemper occurs frequently in domestic dogs, coyotes, and gray foxes (Davidson et al. 1992). Cases of canine distemper in felids in the Americas have included a possible case in an African lion in Canada (Wood et al. 1995): in captive leopards (Panthera pardus), tigers, African lions, and a jaguar (Panthera onca) in southern California: and in captive black leopards in Illinois (Appel et al. 1994). The source of the disease in southern California cats was believed to be raccoons.

Infection with CDV in dogs produces respiratory, gastrointestinal, and neurological clinical signs, commonly
progressing to secondary dehydration, pneumonia, seizures, and death. Many dogs with primary distemper infections never completely recover normal respiratory function. Symptoms of distemper in felids include neurological manifestations as in the African lion epidemic and the captive tiger, and respiratory disease, such as in the snow leopards. African lions in the Serengeti had neurological disease and pneumonia (Roelke-Parker et al. 1996).

Testing for canine distemper includes serology for neutralizing antibodies (IgM and IgG), as well as IFAs on conjunctival smears and oculonasal exudates. The IgM response is typical during acute infection, while IgG levels typically are elevated after 8-12 days. It is unknown what the "typical" antibody response in cats would be to canine distemper, but Appel et al. (1994) found that CDV neutralizing antibody titers were sometimes very low in affected big cats, and that the titer was variable, depending upon the particular strain of CDV employed in the test.

Although canine distemper has gained prominence lately for high visibility epidemics in felids, western mountain lions have likely been exposed by dogs, foxes, and coyotes for years, without apparent outbreaks. However, Roelke-Parker et al. (1996) suggests that the CDV strain affecting African lions may have "extended its host range". Thus, recent data demonstrate that it would be advisable to assay western felids for exposure to canine distemper.

FELINE PANLEUCOPENIA

Panleucopenia, or feline distemper, is a severe viral disease producing diarrhea, vomiting, leucopenia, and death in affected cats. Affected cell types in an animal include all rapidly growing cells: i.e. gastrointestinal epithelium, white blood cell precursors in the bone marrow, and in perinatally infected kittens, cerebellar Purkinje cells. Cats are infected after exposure to infective feces. Although virus persists in the environment for months after being shed from the host. Cats that survive infection are typically immune for life (Scott et al. 1970). Very young kittens typically have solid maternally-derived immunity which wanes by about 6 weeks. Thus the potential for severe epidemics of panleucopenia is determined primarily by the lack of herd immunity due to availability of previously unexposed immature animals.

Wassner et al. (1988) described a severe epidemic in 1979 in bobcats with 11 out of 18 radio-collared bobcats dying of panleucopenia. Field evaluation of seroprevalence documents previously exposed, immune individuals, providing some information of the prevalent herd immunity to the virus. The seroprevalence in Florida panthers was 78% (Roelke et al. 1993), with older cats tending to have higher rates of seropositivity. In California, a seroprevalence of 93% was reported (Paul-Murphy et al. 1994). Levels this high suggest that the likelihood of large scale panleucopenia mortality in western mountain lion populations is low.

FELINE LEUKEMIA

Despite relatively high rates of feline leukemia virus (FeLV) infection and disease in domestic cats and the US, reports of feline leukemia in free-ranging and captive non-domestic felids are infrequent. Presumptive feline leukemia was reported in a mountain lion with pronounce leucopenia (Meric 1984). One case of FeLV in California mountain lion was reported in Sacramento (Jessup et al. 1993). That mountain lion was anemic and lymphopenic, and had generalized lymphoproliferative disease, and possible secondary spirochetosis. This mountain lion obviously had opportunity to interact with suburban feral cats. It is anticipated that feline leukemia could eventually become a significant problem in free-ranging mountain lion populations, especially where overlap with humans and domestic cats occurs.

Infection with feline leukemia virus follows one of two possible clinical courses: transient viremia followed by effective immune elimination of the virus and recovery, or prolonged to chronic viremia and eventual development of disease (Pedersen et al. 1977). Clinical symptoms of FeLV include oral lesions, neuropathy, recurring fevers, immunosuppression and development of secondary infections, anemia, and lymphoid and myeloid neoplasm. The period of latency of the virus from initial infection to onset of symptoms may be months to years. Infection may be acquired via saliva, tears, urine, blood, and feces, and in-utero. However, the virus is labile outside the host, and transmission thus only occurs given close contact between potential hosts.
Several testing procedures are commonly employed to diagnose feline leukemia infection. Notably, most tests rely on detection of viral antigen denoted p27 in blood, serum, or tears. The commercially available ELISA has the advantage of being very fast and easily performed in the field, but has a slight risk of false positives. Confirmation of FeLV antigenemia may be performed with IFA.

Despite a few isolated reports of feline leukemia in nondomestic felids, overall seroprevalence approaches zero. In California, the mountain lion seroprevalence by antigen ELISA was 0 (Paul-Murphy et al. 1994), as it was in Florida panthers (Roelke et al. 1993).

Clearly, future rates of feline leukemia infection in mountain lions are likely to be related to rates in domestic cats with which they are sympatric. Domestic cat FeLV seroprevalence has been reported from 5.1% in mid-Atlantic states (Glennon et al. 1991, who themselves claimed that there might be a bias towards "healthy cats" in their sample), to 10.7% (Stark et al. 1987). Specific rates of FeLV in California domestic cats have not been reported.

FELINE IMMUNODEFICIENCY VIRUS

Feline immunodeficiency virus (FIV) and the related puma lentivirus (PLV) have incited concern and controversy regarding their potential impacts on populations of free ranging felids. Genetically, FIV and PLV are similar to HIV, the agent responsible for acquired immune deficiency syndrome (AIDS) in humans. AIDS (i.e. very low CD4 T-lymphocyte counts, increased susceptibility to opportunistic infections, etc.) has also been observed in FIV-infected domestic cats, but it remained controversial whether any clinical disease in non-domestic felids could be attributed to FIV/PLV infection. PLV is genetically and biologically distinct from FIV (Olmstead et al. 1992), with one study reporting similar structural genes between the virus but distinctly shorter long terminal repeats (LTRs) in PLV (Langley et al. 1994). Domestic cats which were experimentally inoculated with PLV became viremic but had no change in T cells or appreciable disease after 6 months (VandeWoude et al. 1996).

FIV in domestic cats is transmitted by "intimate contact": saliva inoculated via a bite wound and sexual transmission. For large cat species, it is reasonable that ingestion of FIV-infected small felids could also transmit the infection. The disease course in cats is similar to that in humans with HIV, including an initial high level of bloodborne virus associated with local enteritis, followed by low levels of viremia and eventual oscillatory dynamics of virus load and antibody titer, eventually culminating in high viremia again and frank immunosuppression (Ackley et al. 1990). Onset of AIDS is variable, occurring approximately 8 years after initial infection of kittens (Pedersen, UC Davis pers. commun.). Thus the two concerns for potential impact of FIV on mountain lions are whether acutely infected, marginal mountain lions would be "pushed over the edge" by transient diarrhea, and whether chronically infected, asymptomatic mountain lions would survive long enough to succumb to AIDS.

Numerous tests are available for diagnosing infections with FIV, including ELISA, western blot, and IFA. Additionally, viremia may be confirmed by co-cultivating patient blood with domestic cat peripheral blood mononuclear cells (PBMCs). PLV and FIV apparently cross-react in serologic tests (Olmstead et al. 1992). Screening procedures on many felid species have identified seropositive individuals in mountain lions, cheetahs (Acinonyx jubatus), bobcats, tigers, African lions, jaguars, and others. Rates of seroprevalence vary. California lion seroprevalence of FIV was reported as 0 in one study (Paul-Murphy et al. 1994), while Olmstead et al. (1992) reported a California seroprevalence of PLV and FIV of 56.25% (n=9) using immunoblot. They also found 80% seropositivity in Arizona, 50% in New Mexico, and 20% in Wyoming. Florida panther seroprevalence varied from 30% (Barr et al. 1989) to 37% (Roelke et al. 1993).

To date, confirmation of clinical disease attributable to FIV is controversial. Kennedy-Stoskopf et al. (1996) documented inverted CD4/CD8 ratios, indicative of virally induced adverse immune effects. It is not known whether natural pathogenicity differs between PLV and FIV.

A likely source of FIV in mountain lion populations in the west is infected domestic cats. The seroprevalence of FIV in cats in the US varies from 1.2% (Yamamoto et al. 1989), 4.7% (Glennon et al. 1991), 8.06% (Courchamp and Pontier 1994), to as high as 11.3% in a high risk population in Texas (Cohen et al. 1990).

In summary, further data need to address pathogenicity of PLV and FIV in mountain lions before we can adequately assess the risk these diseases have for lion populations. It is fascinating to note that FIV seroprevalence is very high in some populations, even in the absence of FeLV. Thus we cannot attribute high rates of FIV solely to exposure to infected domestic cats. Interesting future research should concentrate on the molecular epidemiology of domestic cat and mountain lion PLV and FIV infections.

FELINE INFECTIOUS PERITONITIS

Significant confusion exists regarding the origin and epidemiology of feline infectious peritonitis (FIP) in populations of domestic cats, where FIP is common and thoroughly described. Thorough understanding of FIP biology in non-domestic felids is even more poorly understood. FIP occurs as a mutant form of the ubiquitous, highly infectious feline enteric coronavirus (FECV) (Poland et al. 1996). Viral strain differences and intrinsic differences in susceptibility of hosts both further complicate FIP epidemiology.
Cases of FIP occur sporadically in cats housed in large groups, reflecting the frequent but sporadic incidence of mutants when FECV is endemic. Superimposed on this sporadic pattern are FIP outbreaks, typically killing 20-50% of all domestic cats in a domestic hold. Outbreaks of FIP have also been described in captive cheetahs (Evermann et al. 1988). While cases of FIP have been described in other species of felid, incidences are rare even with confirmed exposure to the same viral strains that produced FIP in cheetahs (O’Brien et al. 1985). Thus FIP per se appears to be the product of numerous determinants of disease: differences in viral strain pathogenicity (Pedersen et al. 1984 a, b); differences in heritable host susceptibility (Foley and Pedersen 1996); predisposing host factors such as concurrent disease (Cotter et al. 1973, Poland et al., 1996); and underlying host immunocompetence.

FECV and FIPV are antigenically and morphologically identical and are therefore impossible to discriminate based on serology. Thus confirmation of FIP traditionally depends upon histopathological examination of lesions post-mortem. Positive serology is associated with infections with either virus; IgG levels typically remain elevated for months after primary infection. The absolute level of antibodies is not indicative of FIP status; acutely FECV-infected cats may mount fairly high antibody titers ($1:1600$), while many FIP-affected cats have relatively low titers ($1:100-1:400$) (Foley et al. 1997b). In catteries, virtually all cats older than 10 weeks are seropositive (Foley et al. 1997a). Clearly, valid serologic testing of felid populations must evaluate titers as low as $1:25$. Many clinical laboratories have artificial cutoffs for reporting serum titers, due to older prevailing opinion that most cats with FIP had relatively high titers.

Infection with FECV occurs through exposure to infectious feces. In the field warm, moist fecal clumps may retain infectious virus for a few days. Infection with FIP occurs either through direct exposure to FIP (in feces, presumably) or through mutation of that cat's own gastrointestinal FECV strain. Preliminary data indicate that many cats with clinical FIP are not shedding any infectious coronavirus, while those cats which are shedding virus may often shed FECV, not FIPV. Furthermore, some cats exposed to an FIPV may effectively contain or eliminate the infection, potentially via cell-mediated immunity.

Many mountain lions in California have serological evidence of exposure to coronavirus. Paul-Murphy et al. (1994) indicated a 28% seropositivity rate, with all titers from $1:25-1:100$. Florida panthers were 19% seropositive (Roelke et al. 1993). In contrast, the typical pattern in densely housed domestic cat populations is for all cats to be seropositive. It appears unlikely that mountain lions per se exceed the endemic threshold population size; rather endemic infections may have been the result of commingling with infected domestic cats. In either scenario, the risk of major mortality due to FIP in mountain lion populations appears slight unless several events occur; mountain lion or combined mountain lion/domestic cat populations become dense enough to maintain endemic FECV infections, highly virulent FIPV strains are introduced into the lion population, and intrinsic, heritable predisposing factors need to be over represented in mountain lion populations, typically due to genetic impoverishment due to small population size.

CONCLUSIONS

In conclusion, western populations of mountain lions appear not to be in imminent danger of catastrophe due to infectious disease. The population structure characterized by low density, large areas, and large numbers of animals contribute to the protection from devastating disease. In contrast, factors promoting catastrophe include sympathy with feral cats and domestic dogs, small isolated mountain lion populations, and populations with high turnover and constant infusion of large numbers of young individuals. In addition, potential development of new disease strains with greater virulence for mountain lions, such as coronaviruses, rabies, and canine distemper virus could contribute to adverse impacts on mountain lion populations. As for most species of vertebrate, if the host population is already imperiled due to demographic and environmental stochasticity, poor habitat availability, and other stresses, then the added impact of infectious disease can be devastating. Thus the potential for infectious disease to adversely affect mountain lion populations remains greatest in already unhealthy populations, arguing for ongoing scientific investigations into the overall ecological health of mountain lions in the west.

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STANDARDIZING PHOTOGRAPHS OF PUMA TRACKS FOR DIGITAL PROCESSING

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Key words: Mountain Lion, Puma concolor, Tracks, Techniques

Abstract We designed a portable camera mount that provides photographs of animal tracks, taken perpendicular to the substrate, of consistent quality and size. The camera sits on a folding black box. Opposing flash units are mounted at different levels depending on the depth of the track. We identified appropriate filters for the film, aperture, and flash units we used, although these will vary and may be improved upon.

Scientific attention has been directed recently toward using animal tracks to 1) identify species, 2) index populations, and 3) identify individual animals. One aspect of some of these techniques involves computerized measurement of track dimensions and areas. To accomplish computer measurements, the track outlines and other features must first be identified (digitized) for the computer. Tracks traced on acetate or plastic film are relatively easily and accurately digitized, but tracing the tracks in the field requires valuable field time and the tracings may be distorted by parallax. Parallax is caused by light rays that bend when they pass from the glass plate on which the tracing is made to the air above and below the plate. If the eye of the tracer is not perpendicular to the glass at the exact spot being traced, this bending, or parallax, occurs and distorts the image. A similar error can exist in photographs not taken from a perpendicular perspective. Photographs greatly reduce field time, and can eliminate the parallax error if they are taken from a location perpendicular to the substrate the track is on (not necessarily vertical). Photographs, however, must be digitized in the office. If the photographs, or their computer images, are of variable quality and size, the human error involved in identifying the true outlines and features may sometimes be greater than errors made by tracing in the field. Shallow tracks in light-colored substrates often lack detail in photographs, making the outline hard to identify. Deep tracks with side-lighting sometimes contain dark shadows on one side of the track just at the point where the vertical wall of the impression curves toward the horizontal bottom of the track. This area of curvature is where detail is needed to properly identify the outline of the track. The goal of this project is to develop a standardized apparatus and new techniques to enable researchers and wildlife managers to take the best possible photographs of mountain lion tracks. Substrate type and ambient light conditions are two of the major factors affecting the quality of photographs of tracks. Since we have no control over where an animal may walk and leave a track we focused our attention on the light factor to improve our photographs. To eliminate variation in this factor we developed the idea of a "black box" that would enable us to standardize light using camera flash units. We tested single and opposing flash units at various heights on different substrates and depths of tracks. We also experimented with flash filters, lens filters, and various camera settings. The result was a collapsible, portable camera mount, or "black box" designed to provide photographs of tracks taken perpendicular to the substrate, of consistent quality and size.

METHODS

Tests were done to learn proper exposure settings, filters, and number and location of flash units.

Equipment
Nikon F2 camera
35 mm lens
2 ea. Vivitar 2000 flash units
Multi-flash adapter
2 ea flash cords
52 mm. Hoya circular polarizer PL-CIR
52 mm. Tiffen lens filter, red 1
52 mm. Tiffen lens filter, yellow 2(8)
52 mm. Tiffen lens filter, neutral density N.D. O6
Kodak Kodachrome 64 slide film
Dark gray window tint, "Gila" non-reflective, 35% Dark Smoke (for flash filter)

Procedures
We first learned the shortest distance our equipment would focus. Using that as a guide, we constructed a collapsible 15-inch cubic box, with one side open. The opposite side had a circular hole in the center just large enough for the camera lens to fit through. We painted the box black to reduce light reflectance inside. We fitted the flash attachments through horizontal holes cut in the shape of the flash units. The bottoms of the holes were 2 inches, 4 inches, and 6 inches from the bottom of the box. These holes were directly opposite each other on two sides of the box.
Broad bands of synthetic rubber covered the openings and held the flash units in place. We found that a hole in the side of the box, large enough to admit a flashlight was very helpful in aiming and focusing the camera. The hole was covered with a synthetic rubber flap to block sunlight. Lacking such a hole, the camera may be focused by resting the camera case on top of the box, with the lens pointing downwards outside of the box.

Schematic drawings of the box and a materials list are available for those who wish to construct their own "black box." We suggest using thin foam padding glued around the hole to support the camera body evenly so that buttons and levers on the camera body do not cause imbalance and movement. Individual experimentation is advised prior to collecting field data, because variations may occur in power of movement. Different distances from the track to the camera lens will alter the exposure needed. We suggest using thin foam padding glued around the hole in the box, large enough to admit a flashlight was very helpful in aiming and focusing the camera. The hole was covered with a synthetic rubber flap to block sunlight. Lacking such a hole, the camera may be focused by resting the camera case on top of the box, with the lens pointing downwards outside of the box.

For experimental purposes we used tracks made by a live dog (Canis familiaris), and in some cases, tracks were made using silicone molds from mountain lion (Felis concolor) tracks. These tracks represented different substrates and different depths in each substrate. We considered track impressions to be "shallow" between 1 and 3 mm, of "medium" depth from 3 to 7 mm, and "deep" when the impression was more than 7 mm. Substrates included silt, sand, and gravel (USDA soils definitions from Buol, Hale, and McCracken, 1973). Gravel sizes were in the 2 mm to 4 mm size range. 'Light-colored" substrates included fine silica sand, similar to beach sand. Other substrates included sand like that found in desert washes and gravel from decomposed granite.

We photographed the tracks using one flash or two opposing flashes placed at each of the three heights. The flash units were aimed either horizontally or downwards toward the track. We then selected the best combinations of substrate, depth, and flash arrangement/height using criteria described below. Once we established the best physical arrangement for the flash units, we experimented with different filters on the camera lens and on the flash units. Lens apertures of F11, F16, and F22 and shutter speeds of 1/60 second and 1/125 second were used in conjunction with the filter and flash arrangements. The tests reported here were conducted using settings of F16 at 1/60 second. We evaluated the results visually, selecting slides that showed the best detail in areas of the track critical to digitizing the track outline.

RESULTS AND DISCUSSION

Aiming and focusing the camera was not a problem. The outside-the-box procedure described above was sufficient for focusing in the relatively flat areas we used. Our lens and distance combination effectively covered most of the area enclosed in the box, so that if the track was reasonably close to the center of the box, it was near the center of the picture. Tracks comprised only a small part of the photograph. A larger track image would be preferable.

We were able to maintain picture quality by increasing flash height as track depth increased. We suggest varying flash height from 2 inches for tracks 1-3 mm deep to 4 inches for tracks 3-7 mm deep, and either 4 or 6 inches for deeper tracks. Details were more distinguishable when flashes were aimed horizontally as opposed to being aimed at the track. These relationships were consistent in all substrates. However, on light-colored substrates (e.g., silica sand) a single or double layer of window tint was needed over the flash units to decrease light intensity. On dark substrates, such as damp sand or gravel, no flash filters were needed. No flash filter is needed for medium or dark substrates. Either a polarized, neutral gray, or a yellow lens filter may be used on all substrates, and one of them or a red filter, is necessary on light substrates. A faster film with less contrast may show more detail in the shadows. Any variation in film speed will require adjustment of filters.

The choice of a lens filter depends on reflectance of the substrate. With light-colored substrates, we could not close the aperture enough to prevent overexposure, and a filter was necessary. A circular polarizer seemed to improve picture quality most of the time. A neutral filter was only slightly less effective. A yellow lens filter improved picture quality on dark substrates, while a red filter made the pictures too dark on medium to dark substrates. On light substrates, either color worked well. Either colored filter used in combinations with a polarizing or neutral filter made pictures much too dark. Some observers who viewed the pictures liked those taken with colored filters, while others liked those taken with a polarizing filter. The quality was good with either one, and differences were minor.

We found little difference among the various apertures perhaps because we had to many confounding variables. We consider our experimentation in this area to be incomplete. We used a wide-angle lens. It is possible that a longer lens or a zoom lens may provide a larger track image in the photograph. Different lenses may require a different height dimension in the box. Also, a different distance from the track to the camera lens will alter the exposure needed because distance dilutes the amount of light that reaches the lens.

Using a standard distance from the track to the camera focal plane standardized the sizes of the tracks in the photograph and made subsequent measurement and analysis easier. We did place a standard-sized (one inch or one centimeter) square card near the track so that people using image-processing software would have a means for calibration in the picture. The more important benefit of a procedure like ours is to standardize quality of the photographs. We experienced difficulty in finding the proper exposures for different substrates, and some of our experiments provided photographs in which the tracks were difficult to distinguish.
Similar difficulties are encountered in available-light photography in the field, and sometimes such photographs are not of the best quality. The position of the sun determines how much shadow defines the track so that tracks in pictures taken early or late in the day are much more clearly seen. A procedure similar to ours standardizes these variables so that one may expect usable pictures every time from all but the most shallow tracks on the lightest substrates.

If it is necessary to photograph tracks at night, this is the best procedure to use. We do not recommend using a camera-mounted flash, because it eliminates all shadows from all but the deepest tracks, and makes them very difficult to see in the photograph. Furthermore, our procedure makes it possible to obtain measurements from tracks observed at night, with the same accuracy as from tracks observed during daylight hours.

With any flash photography, including our method, it is necessary to watch when the camera is set off to make sure the flash operates. We had some trouble with cords becoming faulty during our work. Part of the solution is to buy professional-quality cords for the flash units, but there is no substitute for verifying each flash.

When a person arrives at a track they want to photograph, they should first determine which track or tracks they want to use. If a person plans to use measurements from the pictures to discriminate among individual pumas, then all the tracks available of both rear feet should be photographed. A set of data from other pumas is necessary to accomplish the comparison, and if only one rear foot is included in the data set, then only the same rear track need be photographed.

Once the tracks to be photographed have been identified, the box may be assembled. The camera and flash units should be fitted with whatever filters are needed as judged by the reflectance of the substrate. Assemble the flash units and cords onto the box at a height determined by the depth of the tracks. Place a measurement device (we like a 1-inch square card) near the track. Put the box over the track so it is stable and the sides are mostly in contact with the ground. Set the camera focus, using the "outside-the-box" method described above, or with the calibrations on the lens, if the setting is known from past experience. Place the camera on the box. Check the focus by shining a flashlight into the flashlight hole and looking through the viewfinder. Adjust as needed. Connect the flash cord to the camera. Release the shutter, watching the cracks around the bottom of the box to make sure the flash units discharged. Most flash units have a light on the back that also shows the discharge state.

The box folds into a 15-inch by 2-inch package, and may be carried in a large day-pack, or strapped onto a smaller one. Other than the box itself, the flash units and cords are the only extra equipment, and they are small and light. This methodology will be useful in specific situations, and not in others. We designed it so that portability would not be an insurmountable problem in those situations where the equipment is needed.

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MOUNTAIN LION RESEARCH IN TEXAS: PAST, PRESENT, AND FUTURE

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Key words: Demography, Ecological Studies, Food Habits, Mountain Lion, Puma concolor, Rio Grande Plains, Texas, Trans-Pecos, Trend Data

Abstract Although mountain lions (Puma concolor) have been reported in all 10 ecological regions of Texas, research has been limited to the Trans-Pecos Region of west Texas. The Trans-Pecos Region has produced >75% of the statewide mountain lion mortalities in the last 10 years. Researchers have focused on mountain lion food habits, spatial patterns, population dynamics, parasites, and behavior. Currently, there are 2 research projects in Texas regarding mountain lion ecology (one in the Trans-Pecos Region and the other in the Rio Grande Plains of south Texas). In this manuscript, we provide a review of mountain lion ecology in Texas, discuss ongoing research of mountain lions in south Texas, and identify research priorities for mountain lions in Texas.

In Texas, mountain lions (P. c. stanleyana) are classified as a nongame animal with no regulations on their harvest. Russ (1997) discusses the public controversy regarding the status of the mountain lion in Texas. Since 1982 the Texas Parks and Wildlife Department (TPWD) has been recording the number of reported mountain lion sightings and mortalities throughout the state. Reports of sightings and mortalities both have increased since the mountain lion database was initiated (Fig. 1). During the past 10 years, the Trans-Pecos region alone has produce >75% of the mountain lion mortalities throughout the state.

Until recently, all ecological studies on mountain lions have occurred on federal land in the Trans-Pecos region of west Texas (Big Bend National Park [BBNP]: McBride 1976, Pence et al. 1976, Leopold and Krausman 1986, Davin 1987, McBride and Ruth 1988, Davin 1989, Waid 1990, Packard 1991, Ruth 1991; Carlsbad Caverns and Guadalupe Mountains National Parks [CACA-GUMO]: Smith et al. 1986). Researchers have focused on mountain lion food habits, spatial patterns, population dynamics, parasites, and behavior. Our goal was to provide a compilation of data on the ecology of mountain lions in Texas, since the majority of mountain lion literature in Texas is in the form of a thesis, dissertation, or government report.

PAST RESEARCH

Food Habits

Mountain lion food habits have been addressed in many studies (McBride 1976, Leopold and Krausman 1986, Smith et al. 1986, Waid 1990). Scat analysis, stomach contents, and kills identified in the field have been used to determine food habits of mountain lions in west Texas. As in most regions, mountain lions primarily use large prey species (mule deer [Odocoileus hemionus], white-tailed deer [O. virginianus], javelina [Tayassu tajacu], elk [Cervus elaphus]) and supplement their diet with a variety of small animals (porcupine [Erethizon dorsatum], striped skunk [Mephitis], black-tailed jack rabbit [Lepus californicus], ground squirrel [Spermophilus spp.], coyote [Canis latrans], gray fox [Urocyon cinereoargenteus], raccoon [Procyon lotor], ringtail [Bassariscus astutus], Rio Grande turkey [Meleagris gallopavo], and turkey vulture [Cathartes aura]). Mountain
lion depredation on cattle, sheep, goats, hogs, horses, and burros has also been reported by McBride (1976) and Smith et al. (1986).

McBride (1976) reported a high incident of livestock kills during 14 years of fieldwork and that these accounted for 55% of the total kills found, whereas, Smith et al. (1986) found livestock to be only 4% of the total kill composition. McBride's (1976) results were based around the work of a predator control officer; hence, results are biased toward livestock depredation. Native big game species were predominant in all studies (McBride 1976, Smith et al. 1986, Waid 1990); deer occurrence ranged between 42-89% and javelina occurrence between 0-37%.

Stomach Contents. Stomach contents (Fig. 3) are probably a less biased indicator of true food habits, but again the mountain lion samples from McBride (1976) may be biased toward livestock (28%) depredation reports. Smith et al. (1986) report mountain lion stomach contents consisted of equal parts of livestock (36%) and deer (36%); however, the sample size (n=24) precludes sound conclusions.

Scat Analysis. Fecal samples probably are the least biased indicator of mountain lion food habits, and the occurrence of small animals may be more likely to be recorded. Deer species occurrence range (Fig.4) from 43-70%, javelina from 0-31%, livestock from 0-14%, porcupine from 2-16%, and other small species from 1-24% (McBride 1976, Leopold and Krausman 1986, Smith et al. 1986).

Composite Samples. We pooled food habits data (McBride 1976, Leopold and Krausman 1986, Smith et al. 1986, Waid 1990) together to form a composite sample for mountain lion scat, stomach, and kills collected in the Trans-Pecos Region of Texas (Fig. 5). Again, the kill and stomach contents analysis are weighted heavily towards the biased livestock occurrence form McBride (1976). The composite scat samples, however, comes from a large number of samples (n=1881) in and around livestock operations and may be a more accurate portrayal of mountain lion food habits in west Texas.

Demography and Spatial Patterns

Age Distribution. Previous researchers (McBride 1976, Pence et al. 1976, Smith et al. 1986, Davin 1987, McBride and Ruth 1988, Davin 1989, Waid 1990, Packard 1991, Ruth 1991) have radio-collared 21 male and 23 female mountain lions in west Texas. Mountain lion radio-telemetry data from the BBNP were redundant since many of the animals were followed by subsequent researchers. We attempted to address the survival of the radio-collared mountain lions in west Texas, but data were incomplete in the published form. We did, however, evaluate the age distribution at time of capture from all the studies. Thirteen (8 M, 5 F) mountain lions were estimated to be #1 yr old, 14

Figure 2. Percent composition of mountain lion kills collected from the Trans-Pecos Region, Texas; data from McBride (1976), Smith et al. (1986), and Waid (1990).

Figure 3. Percent occurrence of mountain lion stomach contents collected from the Trans-Pecos Region, Texas; data from McBride (1976), and Smith et al. (1986).

Figure 4. Percent occurrence of mountain lion scat samples collected from the Trans-Pecos Region, Texas; data from McBride (1976), Leopold and Krausman (1986), Smith et al. (1986), and Waid (1990).
(5 M, 9 F) at 2-3 yrs old, 8 (3 M, 5 F) at 4-5 yrs old, 8 (5 M, 3 F) at 6-7 yrs old, and 1 female was estimated to be 8$^{+}$ yrs old. The age distribution is characteristic of an exploited mountain lion population (Smith 1990).

**Status.** The causes of mortality or status of 44 radio-collared mountain lions in west Texas were assessed (Pence et al. 1976, Smith et al. 1986, Davin 1987, McBride and Ruth 1988, Davin 1989, Waid 1990, Packard 1991, Ruth 1991). Forty-three percent (19/44: 11 M, 8 F) died from predator control efforts or sport hunting, 11% (5/44: 2 M, 3 F) died of natural causes (intraspecific related, disease), 9% (4/44: 1 M, 3 F) died from other causes (capture related, unknown causes) and 23% (10/44: 4 M, 6 F) were alive at the end of their respective studies, and status of 13% (6/44: 3 M, 3 F) of the mountain lions was unknown (dispersed or relocated beyond monitoring range).

**Density Estimate.** We extrapolated density estimates from 4 studies on the BBNP (McBride 1976, Krausman and Ables 1981, Leopold 1984, Waid 1990) and 1 study from the CACA-GUMO area (Smith et al. 1986). We used a conservative density estimate by assuming effective area size to be 1.5x greater than the actual area reported in the study area description. This estimator accounts for mountain lions ranging beyond study area boundaries. Densities were calculated using the number of mountain lions estimated to be on the respective study area/(1.5 x study area size). Our calculations yielded densities that range from 1.39-4.88 mountain lions/1000 km$^2$ on the BBNP and a density of 15.45 mountain lions/1000 km$^2$ for CACA-GUMO.

**Home Range.** Reported home range sizes of west Texas mountain lions were variable (McBride 1976, Smith et al. 1986, Waid 1990). In Andersen's (1983) review of McBride (1976) an average home range size of 1,032 km$^2$ was calculated for both males (n = 2) and females (n = 4), while Waid (1990) reported a home range of 792 km$^2$ for 1 male and an average home range of 159.3 km$^2$ for females (n = 5). Smith et al. (1986) reported even smaller ranges of 207 km$^2$ and 59 km$^2$ for males (n = 4) and females (n = 4), respectively.

**PRESENT RESEARCH**

There currently are 3 mountain lion research projects ongoing in Texas. The TPWD is currently collecting reports of mountain lion sightings and mortalities throughout the state. Russ (1997, this preceding) provides a review of the 14-yr database. The TPWD is also funding 2 ecological studies on the Texas mountain lion. The first is being conducted by TPWD personnel in west Texas on the state owned Big Bend Ranch State Natural Area (BBRNSA). The second study (South Texas Mountain Lion Project [STMLP]) is being conducted by the Caesar Kleberg Wildlife Research Institute at Texas A&M University-Kingsville in cooperation with the TPWD. Research is being conducted on private-ranch lands in the South Texas Plains encompassing 4000 km$^2$. This is the first attempt to study the mountain lion population of South Texas and is the most eastern study other than those of the endangered Florida "panther".

**FUTURE RESEARCH SUGGESTIONS**

**Trend Data**

The statewide mountain lion sightings and mortalities database assembled by the TPWD has been under scrutiny by various public concern groups. With proper assumptions and interpretations, the database can determine long-term trends in mountain lion sighting and mortality reports. We recommend efforts should be made to address some of the fallacies with the database. We caution the use of mountain lion sightings as an indicator of mountain lion distribution. Efforts to accumulate a total count on mountain lion mortalities should be made and supported from all levels in the field rather than volunteered information. Complete data should also be taken on mountain lion mortalities (i.e., sex, weight, morphological measurements-canine measurements). Field personnel should be trained in mountain lion habits and data collection and encouraged to investigate reported sightings and mortalities in areas of the state where the presence of mountain lions is controversial.

**Ecological Studies**

Future radio-telemetry studies in Texas, should be long-term in nature. The 2 existing studies are but 2-3 yr duration and should be continued for another 2-3 years. Efforts should also be made to assess mountain lion populations other than those in the Trans-Pecos Region. The STMLP is the only study that has occurred outside of the Trans-Pecos Region. Future mountain lion research should focus on the other regions that have yet to be studied (i.e., Rolling Plains, Pineywoods, Edwards Plateau, Post Oak Savannah, Coastal Prairies). State personnel should actively pursue mountain lion sightings in these regions to validate their authenticity.

**Management**

Mountain lion research in Texas is in its infancy. Knowledge of mountain lions in Texas (statewide) is inadequate with respect to their distribution, numbers, and basic ecology. The status of a game animal, would allow the TPWD to collect more comprehensive data on mountain lion harvest. Mountain lions in Texas should be managed on a regional level, where regulations are based on the health of and our knowledge of the mountain lion populations in specific areas. Game status, with the use of a stamp or permit would also generate funds for increasing data collection. The several roundtables that have been held regarding the mountain lion in Texas appear to attract the 2 extremes. We suggest a random mountain lion questionnaire to survey the attitude, views, and knowledge of Texans on mountain lion ecology and conservation efforts.

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LITERATURE CITED


COUGAR-HUMAN INTERACTIONS IN BRITISH COLUMBIA

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Key words: British Columbia, Mountain Lion, Puma concolor, Human Interaction

The status of cougars in British Columbia was estimated in 1988 (Hebert, 1988). At that time it had been gradually improving since the earlier days when bounties were in place and seasons were considerably more liberal. Since 1988, season, bag limit and sex restrictions have served to maintain the increase in the majority of cougar populations throughout the province. Mild winters and improved prey populations in many parts of the province have also aided the improvement of cougar populations, as well as several other species of predator.

The relationship between predators and an expanding human population has been changing for decades and even centuries. Human expansion into western North America witnessed extensive predator removal as a result of fear, direct depredation on expanding livestock and human populations, the existing predator density and an extensive predator distribution. Wolves were specifically poisoned and bountied, while other species such as cougar and coyote were indirectly poisoned, bountied, and controlled through a variety of ingenious techniques.

Following this period, predators played a less prominent role in wildlife management, livestock depredation and human interactions. In fact, many if not most wildlife biologists educated in the 1960-80's learned little about carnivore biology, their population dynamics or predation characteristics. As predator populations improved, a better understanding of their role in predator/prey dynamics developed throughout the 1980's and 1990's.

Wildlife research programs have not provided clear recommendations on how to manage cougars to reduce risk of attack on humans. We will present and interpret circumstantial evidence on this issue. Because this is circumstantial evidence, there may be room for more than one interpretation.

Of the more than 40 human attacks in North America, approximately 50 percent of them have occurred in British Columbia, with the majority of those occurring on Vancouver Island and the majority of these occurring on the west coast of the Island. What is unique about Vancouver Island? What parameters might lead to this high incidence and unequal distribution of human attacks?

When it's forests were in an old growth state (1900-1950), Vancouver Island (especially the east side) contained high-density wintering black-tailed deer populations (4-500 mi²) in association with high density cougar populations. At this time wolf populations had not made a comeback and black bear were the only other large carnivore on the Island.

Annual cougar harvests throughout the province averaged 500+ during 1930-55. However, most of the cougar harvest (77%) came from about 60,000 mi² or about 28% of the available cougar area in the province. Vancouver Island contains almost 12,000 mi² or about 20% of the high harvest area. A large proportion of the provincial cougar harvest was coming from the east coast of the Island (4-5000 mi²) at this time. In fact, most of the harvest was occurring in the east coast Douglas fir zone where early logging provided reasonable access.

Cougar harvests was highly heterogeneous because:

a) the east coast had a higher cougar density
b) access occurred here first and expanded throughout the 40's to the 1970's
c) there was higher human habitation and activity
d) there was greater ease in hunting cougar due to lower rainfall and less dense vegetation

Under these exceptional levels of productivity, cougar-human interactions were inversely proportional to human population density and to cougar harvest levels. Almost all cougar attacks, approximately 95%, occurred on the west coast of the Island where human population was sparse, cougar populations were at lower densities than on the east side of the Island and cougar hunting was low to minimal.

There could be two possible reasons for this inverse relationship:
1) cougar ecotypes differ behaviourally from the west side of the Island to the east and differ from all other cougar populations, or
2) hunting has played a major role in reducing cougar-human interactions on the east side of the Island and throughout the province in general.

At this time, it is most likely that hunting and attendant harvest levels have modified cougar behaviour, densities, distribution and age class relationships and their relationship with human populations and have significantly reduced or almost removed cougar-human interactions.
What other evidence supports this relationship? Hebert (1988) suggests that, "The increase in cougar harvest between 1985 and 1988, along with increased sightings, problem animals and general activity, suggests that the cougar populations is responding to these events," namely the termination of the bounty, shorter seasons, and restriction on the harvest of females. These early signs (sightings, problem animals) have persisted and increased throughout the province in direct proportion to increased cougar attacks on humans. Although quantification of many parameters is lacking (cougar density, sex and age class of the population, cougar distribution), attacks clearly are increasing under restrictive cougar hunting regulations and during a period of increase in many if not most prey populations.

Cougar hunting (female harvest) in the East Kootenay region of the interior of the province has been reduced significantly for about 10 years. After a maximum female harvest is reached (usually 10) the entire season is reduced or shut down. This has led to a general increase in the population, higher kitten survival and a greater proportion of 2 year old males in the population. As a result, cougar-livestock and cougar-human interactions have increased significantly. Cougars have entered towns and cities more often (Creston, Elkford, Princeton). In general, humans are seeing them more often and are being stalked more often. Guide-outfitters note that there are considerably more cougars throughout their area.

In order to determine or quantify the causal relationship of cougar-human interactions, many parameters of cougar populations could be manipulated in an experimental manner: total numbers could be changed significantly adjacent to human habitation; population density could be altered; sex and age classes could be adjusted; and spatial distribution could be changed. Similarly, many human parameters could also be adjusted or regulated: hunter numbers; hunter density; human activity and distribution; and road access, etc. However, in most cases the human consequences of these experiments are too severe to justify the science.

Other cougar research in British Columbia indicated that two forms of learning behaviour could affect prey selection by cougars, first, cougars can learn to exploit new prey. In the central part of British Columbia (Caribou-Chilcotin), cougars learn to select large bighorn rams from a California bighorn sheep population as their main prey following the rut (Harrison and Hebert, 1988). In most other cougar research programs, sheep play a less important role in cougar diet. How female cougar learned to select vulnerable bighorn rams following the rut is unknown. However, they did learn and they were very successful at producing and maintaining kittens, with this highly nutritious and available food source. The ability to choose humans and their pets as a food source could be accomplished in a similar manner.

Second, cougars can learn to avoid an area there they are harassed. During the study of Harrison and Hebert (1988), female cougar and their growing kittens were collared and recollared (kitten collaring began at 3 months of age and they were recollared approximately every 3 months). To escape harassment, 2 females with kittens changed locations on the sheep range. After repeated collaring, they swam both the Chilcotin and Fraser rivers (in flood) at least once and in 1 case, twice, apparently to escape harassment. We believe that harassment can be used to reduce cougar-human interactions in specific zones. Our cougar were not hunted or killed, they were simply harassed to a point where life in another area was more comfortable.

British Columbia has supported a significant cougar population and harvest for over one hundred years. There is very little likelihood that this will change over the next 100 years or that the cougar population will be threatened by hunting. However, cougar populations will continually adjust to, or be adjusted by human activities.

The cougar population on the east coast of Vancouver Island has been highly regulated for a similar time period. Their food has peaked and declined and increased again. They have endured bounties and poison and significant increases in the wolf population. Human population has increase, yet cougar-human interactions have remained at a manageable level.

On the west coast, hunter harvest is minimal allowing cougar-human interactions to sustain itself at significantly higher levels. Similarly, where hunting has been reduced throughout the province and/or where cougar populations have increase, cougar sightings and attacks on humans have increase.

Quantification of the relationships between cougars and human attacks may be somewhat lacking, however, the subjective relationship and its consequence are very clear.

In 1988, it was estimated that British Columbia contained 3000-3500 cougar, as a huntable population, among a human population of 2.5-3 million. California has a cougar population of 5000+ that isn't hunted, among a human population of 30+ million. The relationship of these numbers in each jurisdiction, each with their set of unknown modifying factors, will be an interesting experiment that will unfold throughout the next 5 years.

**CONTRIBUTIONS TO THE IDENTIFICATION OF Puma concolor concolor**
Abstract  The identity of mountain lion subspecies in Brazil is yet to be studied. The most controversial subspecies is *Puma concolor concolor* which inhabits semi-arid regions as well as Atlantic forests and savannas. The range of *P. concolor* has changed three times since the first description. The range now extends from northeast Brazil south through Uruguay to northeastern Argentina and Paraguay. Up till now the subspecies description of *P. concolor* has been based on three skulls: one male from the northeastern Brazil; and a male and female form southeastern Brazil. The purpose of this paper is to identify variations within the range of *P. concolor* and provide information for further studies on the taxonomy of Brazilian mountain lions. Such information may be valuable to define management plans for the species at the subspecific level. Twenty-nine skulls (15 male and 14 female) from two regions within the range of *P. concolor*) were compared. Differences are reported on measurements of both males and females.

Brazil is well known for its extensively forested amazon and the ecologically rich swamp regions of the Pantanal. Protected by extensive forest cover, mountain lions and other species that require large home ranges can still sustain healthy populations in those areas. *Puma c. concolor* occupies a more fragmented environment as a result of intensive land development by man, which includes northeast, southeast and south Brazil, northeast Argentina, eastern Paraguay and Uruguay. In the 2 southernmost states of Brazil, mountain lions find refuge mainly on mountains above 800 m (Ihering 1949, Mazzolli 1993). Uncontrolled poaching, absence of effective biological reserves and a lack of population counts and monitoring raise questions about the subspecies' current status.

Because the *P. c. concolor* range is so extensive and diversified, and so few descriptions are available, one may argue the presence of only one geographical race. In order to augment the available information on *P. c. concolor*, several specimens are described by means of cranial measurements. Populations from the south and southeast Brazilian range of *P. c. concolor* are statistically compared. These data are compared with data from the type locality (northeast Brazil), and specimens from northeast Argentina and Uruguay.

The evolutionary importance of subspecies and the validity of applying subspecific names based on subtle differences between populations are discussed (e.g., Cracraft 1989). We consider that biodiversity must be preserved at all taxonomic levels, and we agree with Chambers and Bayless (1983) that subspecies often are the best available description of variability within a species.

RESULTS

The measurements of all collected data are in Table 1. Results of the t-test that account for discriminating the groups are shown in Table 2, Table 3 and Fig. 3. The skull measurements with the most discriminating power for males are postorbital length (P=0.00), interorbital and zygomatic breadth (P=0.02), length of mandible (P=0.05), cranium width (P=0.07), total length (P=0.08), and for female discrimination are breadth of rostrum (P=0.01), basal length (P=0.02), total length, condilobasal length and length of mandible (P=0.05), and length of palate (P=0.08).

Southern (S) mountain lions have larger skull dimensions (males wider and females longer) than mountain lions from the Southeast (SE) group. Results with probabilities slightly lower than 95% were included because of the small sample size may change the probabilities.

METHODS

Skull measurements (Fig. 1) of 15 adult male and 14 adult female mountain lions from south and southeastern Brazil (Fig. 2) were collected using a 300mm sliding caliper. The measurements were those used by Ximenez (1973), with greatest length added by the author. T-tests were performed using Systat 5.0 statistical package for Macintosh. Males and females were analyzed separately because of their strong sexual dimorphism (Mazzolli 1992). The t-test assumes the equality of variances and normal distribution of the samples (Zar 1974). The equality of variances for each group were compared using the formula $F=s_1/s_2$ (Zar 1974), and normality was verified by measuring skewness.
Figure 1. Skull of an adult felid showing the measurements taken. Drawing from Ximenez (1973). 1- Greatest length (G.T): length from the prosthion to inion. 2- Basal length (B.L.): distance from the prosthion to basion. 3- Condylobasal length (C.L.): distance from prosthion to condilion. 4- Length of palate (L.P.): distance from the prosthion to palathion. 5- Nasal length (N.L.): (diagonal) greatest distance from anterior to posterior ends of nasal. 6- Zygomatic breadth (Z.B.): greatest distance between outer borders of zygomata. 7- Breadth of rostrum (B.R.): greatest distance between outer alveolar border of the superior canines. 8- Interorbital breadth (I.B.): least distance between orbits. 9- Postorbital breadth (P.B.): least cranium breadth at postorbital processes. 10- Cranium width (C.W.): greatest distance between outer borders of cranium. 11- Superior tooth row, alveolar distance (S.T.R.): distance from most posterior end of superior canine at alveolar border to most posterior end of Pm4 at alveolar border. 12- Inferior tooth row (I.T.R.): distance from most posterior end of inferior canine at alveolar border to most posterior end of inferior canine at alveolar border. 13- Upper carnassial, crown length (U.C.): greatest anterior-posterior diameter of crown. 14- Length of mandible (L.M.): distance between most anterior point of mandible to most posterior point of articular condyle.

DISCUSSION

Nelson and Goldman (1929) assigned Sâo Paulo (SP), in southeast Brazil, as type locality of Felis concolor (Felis concolor Linnaeus). Goldman (1946) changed the type locality to French Guiana, and Cabrera (1957) accepted it. Hershkovitz (1949) assigned F.c. greeni (Nelson and Goldman, 1931) from Rio Grande do Norte, northeast Brazil, as a topo type of F.c. concolor based on the fact that Linnaeus (1771) had given Brazil as type locality of F. concolor, based on the assumption that the skull from Piracicaba (SP) used to describe F.c. capricornensis was abnormal (Fig. 4, 5, and 6).

Goldman (1946) used one male skull to describe the subspecies F.c. greeni, and one male and one female to describe F.c. capricornensis. Herskovits (1949) based his assumptions on literature to make the synonyms thus leaving the description of F.c. concolor with 3 samples.

In this study we were able to gather information from the south (S) and southeast (SE) Brazilian range of P.c. concolor. Instead of grouping them as a single subspecies, we performed a comparison between the two groups. Data for other sources are summarized in Tables 4 and 5. The only data we have on P.c. concolor from the type locality (Northeast Brazil) is Nelson and Goldman’s (1931) F.c. greeni specimen. Figure 3 compares mountain lion populations from S and SE Brazil, and includes some of Goldman’s (1946) measurements of F.c. greeni and F.c. capricornensis. F.c. Greeni falls outside the range of both the...
Table 1. Morphometric data for mountain lion skulls from south and southeast Brazil. Those specimens without a catalogue number have their locality listed instead. The column PROV (province) abbreviates Brazilian states.

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<td>7/82</td>
<td>M</td>
<td>202.00</td>
<td>173.60</td>
<td>181.20</td>
<td>78.30</td>
<td>42.30</td>
<td>47.60</td>
<td>58.00</td>
<td>67.00</td>
<td>133.50</td>
<td>54.60</td>
<td>145.00</td>
<td>22.70</td>
<td>71.40</td>
</tr>
<tr>
<td>UFSC-0344</td>
<td>RS S</td>
<td>5/87</td>
<td>M</td>
<td>205.00</td>
<td>168.20</td>
<td>181.20</td>
<td>78.30</td>
<td>42.30</td>
<td>47.60</td>
<td>58.00</td>
<td>67.00</td>
<td>133.50</td>
<td>54.60</td>
<td>145.00</td>
<td>22.70</td>
<td>71.40</td>
</tr>
<tr>
<td>UFSC-0319</td>
<td>SC S</td>
<td>7/75</td>
<td>M</td>
<td>177.60</td>
<td>148.60</td>
<td>161.40</td>
<td>73.00</td>
<td>42.00</td>
<td>55.40</td>
<td>62.00</td>
<td>117.20</td>
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<td>20.20</td>
<td>67.90</td>
<td></td>
</tr>
<tr>
<td>UFSC-0387</td>
<td>SC S</td>
<td>4/89</td>
<td>M</td>
<td>208.00</td>
<td>176.60</td>
<td>189.20</td>
<td>84.00</td>
<td>38.60</td>
<td>42.50</td>
<td>79.50</td>
<td>71.30</td>
<td>140.70</td>
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<td>146.30</td>
<td>22.70</td>
<td>72.70</td>
</tr>
<tr>
<td>UFSC-0351</td>
<td>SC S</td>
<td>3/84</td>
<td>F</td>
<td>174.20</td>
<td>147.00</td>
<td>159.00</td>
<td>68.90</td>
<td>47.80</td>
<td>31.50</td>
<td>43.10</td>
<td>51.90</td>
<td>60.90</td>
<td>112.00</td>
<td>44.00</td>
<td>109.00</td>
<td>21.10</td>
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<tr>
<td>UFSC-0320</td>
<td>SC S</td>
<td>4/64</td>
<td>F</td>
<td>172.80</td>
<td>146.00</td>
<td>158.50</td>
<td>70.00</td>
<td>50.30</td>
<td>33.50</td>
<td>43.40</td>
<td>51.90</td>
<td>60.90</td>
<td>112.00</td>
<td>44.00</td>
<td>109.00</td>
<td>21.10</td>
</tr>
<tr>
<td>UFSC-0381</td>
<td>SC S</td>
<td>7/76</td>
<td>F</td>
<td>178.30</td>
<td>151.60</td>
<td>163.20</td>
<td>70.00</td>
<td>48.20</td>
<td>29.80</td>
<td>34.70</td>
<td>52.80</td>
<td>60.00</td>
<td>120.00</td>
<td>45.60</td>
<td>114.20</td>
<td>19.60</td>
</tr>
<tr>
<td>UFSC-CURITIBANOS</td>
<td>SC S</td>
<td>11/91</td>
<td>F</td>
<td>178.00</td>
<td>153.00</td>
<td>166.00</td>
<td>74.50</td>
<td>53.40</td>
<td>34.70</td>
<td>37.50</td>
<td>65.70</td>
<td>63.40</td>
<td>121.00</td>
<td>47.50</td>
<td>121.80</td>
<td>21.40</td>
</tr>
<tr>
<td>FURB-ALTO VALE</td>
<td>SC S</td>
<td>7/90</td>
<td>F</td>
<td>171.10</td>
<td>149.90</td>
<td>156.90</td>
<td>71.10</td>
<td>48.50</td>
<td>29.00</td>
<td>39.50</td>
<td>53.30</td>
<td>62.10</td>
<td>115.50</td>
<td>46.20</td>
<td>115.00</td>
<td>20.80</td>
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</tbody>
</table>

Specimens are deposited at MZUSP- Museum of Zoology of the University of Sao Paulo-USP, UFSC- Federal University of Santa Catarina, FURB- University Foundation of Blumenau, M.M.- Author’s private collection.

S and SE group. It is smaller in size (greatest length 189.4mm) and has a larger interorbital breadth (42.5 mm). Also F.c. greeni measures 52.5 mm for inferior tooth row, while the range of S and SE vary from 66.00-73.30 mm. Goldman's (1946) F.c. capricornensis male falls outside the range of the samples from the SE group, which it is supposed to belong to. Goldman's (1946) F.c. capricornensis female falls in the SE group, although it is below the average (Fig. 3).
Table 2. Statistical comparison of cranial measurements (in mm) of male mountain lions from South and Southeast Brazil. Table shows only statistics of data with highest probabilities of discriminating the groups. Data are mean \( \bar{G} \), standard deviation (SD), sample size (n), range (MIN-MAX), T-test (T), Probability (P).

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Southeastern male pumas</th>
<th>Southern male pumas</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{G} )-SD(n)</td>
<td>MIN-MAX</td>
<td>( \bar{G} )-SD(n)</td>
<td>MIN-MAX</td>
</tr>
<tr>
<td>Greatest Length</td>
<td>199.70±3.27 (4)</td>
<td>195.80 - 203.80</td>
<td>206.11±2.61 (8)</td>
<td>195.70 - 214.20</td>
</tr>
<tr>
<td>Zygomatic Breadth</td>
<td>133.32±2.30 (5)</td>
<td>130.90 - 135.70</td>
<td>141.20±5.86 (8)</td>
<td>128.00 - 146.30</td>
</tr>
<tr>
<td>Interorbital Breadth</td>
<td>36.94±1.15 (5)</td>
<td>35.80 - 38.40</td>
<td>39.38±1.90 (9)</td>
<td>36.80 - 42.30</td>
</tr>
<tr>
<td>Postorbital Breadth</td>
<td>38.52±2.08 (5)</td>
<td>35.30 - 40.40</td>
<td>43.33±2.16 (9)</td>
<td>40.30 - 47.60</td>
</tr>
<tr>
<td>Cranium Width</td>
<td>69.08±1.72 (7)</td>
<td>67.00 - 72.40</td>
<td>71.33±1.94 (8)</td>
<td>67.00 - 67.60</td>
</tr>
<tr>
<td>Length of Mandible</td>
<td>134.92±1.77 (6)</td>
<td>132.00 - 136.80</td>
<td>138.85±4.15 (8)</td>
<td>131.70 - 142.90</td>
</tr>
</tbody>
</table>

Figure 3. Results of cranial measurements (mm) of male and female mountain lions from South and Southeast Brazil. Figure shows only statistics of data with highest probabilities of discriminating the groups. Data are mean, standard deviation, sample size (n), range and Probability (P). Highlighted with a black triangle are measurements from the male type of *F. c. capricornensis* (Goldman, 1946), supposedly from Southeast Brazil, and the female from the same region. Note that the male fits better on the South group. Highlighted with an open triangle is Nelson and Goldman (1931) *F. c. greeni*. *F. c. greeni* is outside the range of samples from South and Southeast Brazil, in two measurements as shown. It has a smaller skull and a broader interorbital breadth. The adult male collected by Ximenix (1972) also falls in an undefined group.

Table 3. Statistical comparison of cranial measurements (mm) of female mountain lions from South and Southeast Brazil. Table
shows only statistics of data with highest probabilities of discriminating the groups. Data are mean, (G), standard deviation (SD), sample size (n), range (MIN-MAX), T-test (T), Probability (P).

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Southeastern female pumas</th>
<th>Southern female pumas</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-SD(n) MIN-MAX</td>
<td>G-SD(n) MIN-MAX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greatest Length</td>
<td>171.10±4.34 (8) 165.00 - 177.60</td>
<td>175.43±2.61 (6) 171.10 - 178.30</td>
<td>-2.16</td>
<td>0.05</td>
</tr>
<tr>
<td>Zygomatic Breadth</td>
<td>143.25±4.38 (8) 136.00 - 148.60</td>
<td>148.97±2.96 (6) 146.00 - 153.00</td>
<td>-2.75</td>
<td>0.02</td>
</tr>
<tr>
<td>Interorbital Breadth</td>
<td>156.15±4.13 (8) 149.70 - 161.40</td>
<td>160.70±3.30 (6) 156.90 - 166.00</td>
<td>-2.21</td>
<td>0.05</td>
</tr>
<tr>
<td>Postorbital Breadth</td>
<td>69.78±2.51 (8) 65.80 - 73.50</td>
<td>72.02±1.60 (6) 70.00 - 74.50</td>
<td>-1.90</td>
<td>0.08</td>
</tr>
<tr>
<td>Cranium Width</td>
<td>43.40±1.72 (7) 41.00 - 46.00</td>
<td>46.34±0.71 (5) 45.60 - 47.50</td>
<td>-3.57</td>
<td>0.01</td>
</tr>
<tr>
<td>Length of Mandible</td>
<td>113.81±3.87 (7) 108.60 - 118.60</td>
<td>118.28±2.50 (5) 115.50 - 121.00</td>
<td>-2.25</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Cabrera (1961) describes 3 males, 1 juvenile and 2 adults, with their respective skull measurements, from Missiones, northeast Argentina, which he considered to be the same subspecies as Goldman’s (1946) *F.c. capricornensis*. The adult skull measurements from Missiones seem to deviate somewhat from the SE group, mainly due to a much wider zygomatic arch (139 mm) and above average interorbital breadth (37.8 and 38.8), but they seem to fit in the S group. Another description from the groups analyzed here. Its postorbital breadth is wide enough to place it in the S group (41mm), but the interorbital breadth is narrower than any of the samples from the SE group (34.8 mm).

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<tbody>
<tr>
<td>F.c. greeni</td>
<td>Nelson and Goldman (1931)</td>
<td>249896</td>
<td>Curraes Novos, R.N.-BR.</td>
<td>M</td>
<td>189.4</td>
<td>169.0</td>
<td>132.5</td>
<td>64.8</td>
<td>42.5</td>
<td>72.0</td>
<td>16.7</td>
<td>26.7</td>
<td>52.5</td>
<td>20.0</td>
<td>10.5</td>
<td>15.6</td>
<td>11.5</td>
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<tr>
<td>F.c. capricornensis</td>
<td>Goldman (1946)</td>
<td>100018</td>
<td>Piracicaba, S.P.-Br.</td>
<td>M</td>
<td>204.2</td>
<td>183.2</td>
<td>139.2</td>
<td>73.9</td>
<td>39.9</td>
<td>73.0</td>
<td>17.8</td>
<td>28.8</td>
<td>63.0</td>
<td>23.5</td>
<td>11.5</td>
<td>17.4</td>
<td>13.9</td>
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<tr>
<td>F.c. capricornensis</td>
<td>Goldman (1946)</td>
<td></td>
<td>Sao Paulo-BR.</td>
<td>F</td>
<td>163.5</td>
<td>152.0</td>
<td>59.2</td>
<td>31.1</td>
<td></td>
<td></td>
<td>17.4</td>
<td>25.6</td>
<td>52.4</td>
<td>21.9</td>
<td>10.8</td>
<td>17.4</td>
<td>11.0</td>
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</thead>
<tbody>
<tr>
<td>F.c. capricornensis</td>
<td>Cabrera (1961)</td>
<td>MACN 49-470</td>
<td>R. Uruguai, Argentina</td>
<td>M</td>
<td>204.0</td>
<td>186.0</td>
<td>139.0</td>
<td>37.8</td>
<td>80.0</td>
<td>16.6</td>
<td>44.6</td>
<td>56.0</td>
<td>71.2</td>
<td>23.2</td>
<td>58.5</td>
<td>22.0</td>
<td>12.0</td>
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<td></td>
</tr>
<tr>
<td>F.c. capricornensis</td>
<td>Cabrera (1961)</td>
<td>MACN 48-344</td>
<td>R. Aguarai-Guaçu, Argentina</td>
<td>M</td>
<td>200.0</td>
<td>175.5</td>
<td>139.0</td>
<td>38.8</td>
<td>79.0</td>
<td>13.4</td>
<td>39.4</td>
<td>54.0</td>
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<td>22.6</td>
<td>57.8</td>
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<tr>
<td>F.c. ssp. Ximenez (1972)</td>
<td>MNHN 1933 Dept. artigas-Uruguai</td>
<td></td>
<td></td>
<td>M</td>
<td>187.6</td>
<td>175.6</td>
<td>34.8</td>
<td></td>
<td></td>
<td></td>
<td>48.4</td>
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<td>23.5</td>
<td>155.6</td>
<td>41.0</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 6. Distribution of F.c. discolor and F.c. concolor according to Hershkovitz (1959).

Figure 7. Climate division of Brazil. Notice the semi-arid region of northeast Brazil, where the type of Puma concolor (Nelson and Goldman’s 1931 F.c. greeni) were collected.
CONCLUSION

The differences found between the south and southeast Brazilian groups of mountain lions and the size of the sample analyzed suggest we have identified a new subspecies. However, all specimens come from a restricted area with no specimens available to suggest clines or gradations between populations. The populations are about 500 km apart, with similar vegetation types and no complete geographic barrier to justify this dissimilarity (see Fig 7). Migration between populations may not be enough to assure the same phenotype. There is no definitive answer now, but before we do have the answer to this biological questions we suggest treating these as distinct variations as a precaution if genetic variability is to be preserved.

The type locality (northwest Brazil) here represented by only 1 specimen with 3 measurements outside the range of south and southeast Brazilian populations. It does not seem to be just a clinal variation. Two of the measurements are smaller, as expected from a specimen collected near the equatorial line, but is has a wider interorbital breadth, wider (also outside the range) than the population from the northern region of Brazil at about the same latitude (Mazzolli 1992). The vegetation of northeast Brazil is xerophic and the climate is semi-arid with several months of drought, favoring the occurrence of a distinct subspecies (Fig 7). Albeit based on 1 sample, the measurements fall outside the range of the group. Chances are that high human occupation on the range of *P. concolor concolor* (Fig 8) will lead to more fragmented habitats, decreasing the chances of emigration between populations.

The mountain lions from northeast Argentina and South Brazil seem to belong to the same group, although a larger sample from Argentina is preferable before we draw any conclusions.

The specimen collected in Uruguay does not fit in any of the groups we analyzed. But again, it is only one specimen and we have not examined the specimen first hand. Based on what we have, however, we also recommend conservation measures to protect them as a valuable stock of genetic variation. A suggested map of subspecific variation based on our results can be seen in Fig. 9.

ACKNOWLEDGMENTS

We thank biologists Américo Ribeiro Tunes and Marlise Becker, from the IBAMA-Santa Catarina for their continuous support. We thank Dr. Paulo Vanzollini and Professor Eraldo Britski from the São Paulo Museum of Zoology (MZUSP) for allowing us to examine their collection. Dr. Juan Alfredo Ximenez Trianon of the Department of Biology of the Federal University of Santa Catarina-UFSAC, by leading the opening of a division for mammal studies at this institution allowed us to engage in...
the study of mountain lions.

LITERATURE CITED


EFFECTS AND PATTERNS OF MOUNTAIN LION PREDATION OF LIVESTOCK ON SMALL AND MEDIUM SIZED PROPERTIES IN SANTA CATARINA, BRAZIL


Keywords: Brazil, Livestock, Mountain Lion, Predation, Puma concolor

Abstract
The effects of mountain lion predation on livestock from 15 different farms were analyzed. Surveys were done from 1993 through 1995. The effects of predation are weighed against losses to other factors. The patterns of predation were recorded when possible, including period of day, frequency during the year, climate and livestock management.

Livestock losses to mountain lion predation is probably the greatest source of conflict between humans and this felid. According to Currier (1983) it is likely that persecution by humans is the main cause of mountain lion mortality. Studies of predator-livestock interactions should ultimately furnish information to diminish livestock losses and mountain lion hunting. This information is especially important in areas where these predators are found in low numbers and there is interest in protecting their populations and avoid conflicts with man.

Jaguars (Panthera onca) are nearly extirpated from the study area, and maned wolves (Chrysocyon brachyurus) are rare and geographically restricted to few locations, making the mountain lion the primary predator responsible for attacks on livestock.

STUDY AREA
The study area lies westward of the mountainous areas of Serra Geral, State of Santa Catarina, Brazil, and includes the counties of Lages, Bom Retiro and Rancho Queimado. The Serra Geral is part of a plateau formation extending from the south to northwest Brazil, formed through a series of basaltic lava spills. It is characterized by steep cliffs covered with dense Ombrophilous Forest (Atlantic Forests) in southern Brazil up to 800 meters. Between 800-1,890 meters the vegetation changes to cloud forest, a pioneer association within the Mixed Ombrophilous Forest (Araucaria Pine Forest). Extensive natural fields (Steppe) are found above and westward of the cliffs, with patches of cloud forest. Most of the Araucaria Forest has given way to cloud forest and fields, as a consequence of expanding livestock enterprises.

Also within the study area are Dr. Pedrinho and Itaiópolis counties, within the domains of both Atlantic and Araucaria Forest (Fig. 1 and 2).

METHODS
In 1988 the authors began responding to complaints from farmers who reported livestock losses to mountain lions. The complaints were usually made to the Brazilian Institution of Environment (IBAMA), which redirected calls to the staff. Some of the resulting data on mountain lions have been published in Mazzolli (1993), but all information concerning livestock are summarized here, including data collected in 1994. Most livestock loss information from earlier years could not be included in some analysis because we lacked a systematic questionnaire; however, figures 9-13 include earlier data. Farms also lacked recorded information on losses, and we found that 2 years back is the best we could expect from farm keeper's memory without too many biases. When asked before this time frame, the keeper usually did not remember details of weather, time, livestock positioning, and livestock losses.

Number of lions killed were mainly based on skulls collected from the visited farms, and distinguished by sex based on strong dimorphism (Mazzolli 1992). The skulls were divided by age according to cementation of skull fissures.

Because there is no government refunding for livestock losses to predators in Brazil, the information given are accurate, as long as keepers would identify livestock losses to lions. Several questions concerning mountain lion behavior were asked (e.g. dragging and burying carcasses, tracks, lion
routes, sightings, vocalization). Several farms in the same region were visited to check consistency of attacks to livestock, and some have been visited a few days after depredation incidents, although not all of them have been included in this paper.

Livestock were converted to US Dollars/head to standardize units and avoid underestimating cattle losses. Because of insufficient data on age class herds were considered as belonging to the same weight or price class. Cost/head estimates include the following: cattle $210.00, goat $50.00, sheep $50.00, swine $60.00. Prices are based on local market.

Because the methodology involved visiting farms that suffer attacks from mountain lions, few farms within mountain lion range with no attacks to livestock were visited.

RESULTS

Six farms covered 40-100 ha, four covered 150-400 ha, and five have covered 500-2,500 ha, averaging 840 ha (Table 1). The majority of farms use livestock breeding seasons to protect newborn livestock from winter stress, when temperatures may drop to -10°C in some areas. Livestock is raised loose on wide ranges. Figure 3 compares...
Figure 2. Map of the State of Santa Catarina, showing original distribution of vegetation (GAPLAN, 1986).

Figure 3. Livestock losses (in % of US$) from all studied farms (n=number of sampled farms) to mountain lions compared to losses due to other factors.

Figure 4. Comparison of Cattle losses between farms (in % of US$) to mountain lion predation and to other factors.
Cattle losses do not demonstrate a pattern across the farms in mountain lion habitat (Fig. 4). Only four out of twelve cattle ranches suffered losses to mountain lions. Cattle losses to other factors are high, and are usually due to diseases, falls from cliffs, and probably theft. Sheep and goats, on the other hand, are consistently depredated (Fig. 5 and 6). Swine losses also show inconsistency, but unlike cattle, attacks from mountain lion may be camouflaged in the "other factor" category (Fig. 7). Livestock losses for 1994 are shown in Fig. 8.

Of a total of 37 records, 41% (n=15) of all mountain lion attacks occurred in winter, 30% (n=11) spring, 24% (n=9) autumn, and 5% (n=2) in summer (Fig. 7). Of all recorded attacks, 54% (n=7) were in rainy weather (including drizzle), 31% (n=4) in good weather, 8% (n=1) under rain and fog, and 8% (n=1) under fog. Rain in mountain areas is usually associated with fog, so we believe the rain and fog numbers are underestimates. Also, we had several complaints of mountain lion attacks under fog conditions which were unrecorded. Night attacks represent 92% (n=11) of all attacks, and daytime attacks represent 8% (n=1).

The sex ratio of the livestock predators harvested by farmers and hunters is 1.3F:1M (13 M, 10F). Considering age of harvest, 1.1 subadults are harvested for each adult (5 adult males, 5 adult females, 5 subadult males, 3 subadult females, 3 young).

Figure 5. Comparison of Goat losses between farms (in % of US$) to mountain lion predation and to other factors.

Figure 6. Comparison of Sheep losses between farms (in % of US$) to mountain lion predation and to other factors.
Figure 7. Comparison of Swine losses between farms (in % of US$) to mountain lion predation and to other factors.

Thirteen of fourteen farms (93%) within mountain lion habitat were above 800 meters. One was at 650 meters, but consisted of very rocky and irregular terrain, with steep hills and extensive native and planted forests.

DISCUSSION

Most farms within mountain lion range do not have problems with mountain lion attacks on cattle. The felid prefers more vulnerable prey, like sheep and goats. Mountain lions can take large prey when necessary, Hornocker (1970) reports that in Idaho elk (*Cervus canadensis*) averaging 380 lb were preyed upon more intensively than mule deer (*Odocoileus hemionus*) which averaged 140 lb., due to the declivity of the terrain.

Hoogesteijn et al. (1992) reported mountain lions were responsible for losses of calves up to a few months old, while losses of calves about 2 years old were attributed to jaguars. This may be due to the smaller size of mountain lions in the tropics. In our study, farms that loose cattle suffer losses of newborn and 2 year old calves. We converted Hoogesteijn et al.’s (1992) data and compared it with our data. Instead of considering percent loss by age, we considered one age stock. Hoogesteijn et al. (1992) studied cattle losses at three farms, the first averaged 0.4% lost in 4 years, the second averaged 1.5% lost in 3 years, and third lost 0.13% of its cattle annually (Table 3). The third farm did not keep calves near forested areas. Farms in Santa Catarina are usually fenced with barbed wire, but frequently forested patches are included in the fenced area where animals often browse. Considering only the farms that actually lost cattle, our results show a 0.38% average among 5 samples (Table 4).

The Cerro Azul farm in Dr. Pedrinho County lost 3 head in 3 different attacks, and 5 more unsuccessful attacks resulted in 1 calf with a nose perforation. The calves were a few months old. The attack locations were in pin (*Pinus elliottii*) forest some distance from the house, which may facilitate the mountain lion's approach. According to the keeper, collared peccaries (*Tayassu tajacu*) and deer (*Mazama* spp.) are relatively abundant, and mountain lion tracks are seen following collared peccaries. Although wild prey seemed available, mountain lion attacks on the farm cattle were intense. Another farm, Mineiros, also had cattle in a vulnerable position. The farm is surrounded by a cliff 100 meters higher than the farm ground, and cattle grazed in a field with scattered bush forest. In this case, the calve were about 2 years old. The farm also had the highest sheep and goat losses (in percentage of its stock) to mountain lions and swine to other causes. The Cabanha Sto. Cristo farm lost 3 young calves to mountain lions. The area is close to the Pelotinhas River and surrounded by cliffs and forest. The area is rich with wild prey such as capybara (*Hidrochaeris hidrochaeris*), paca *Agouti pacas*, agouti (*Dasyprocta azarae*), deer and armadillo (*Dasypus* spp.). The Saulo Yung farm at Paraiso de Serra had a 2 year old calf loss after removing sheep from the farm. The farm is surrounded by cliffs.

Sheep and goat loses were high on all farms. There are three exceptions: at Sitio Ruck where goat losses were high (35.48% of 62 head) but there were sheep losses. This may be due to the small herd number (6). The farmer had a larger sheep herd, but has sold most of it because, he reported, they were more vulnerable to mountain lion attacks. Other exceptions are Dona Olindina with 25 sheep with no losses, Potreiro Velho with 2.94% sheep losses (1 of 34 head), although both contain good mountain lion habitat with extensive vegetation and cliffs. These farms keep livestock penned at night beside the main house, and had
Table 1. Summary of livestock operations visited for this study, including number of head at each ranch. The management column indicates if the livestock were penned at night or not.

<table>
<thead>
<tr>
<th>Farm Name</th>
<th>Area (Ha)</th>
<th>Year</th>
<th>Livestock</th>
<th>Total</th>
<th>Losses-Lions</th>
<th>Losses-Other</th>
<th>Management</th>
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Table 2. Records of mountain lions killed from 1988 to 1995.
Table 3. Data from Hoogesteijn et al. (1992), showing cattle mortality from jaguar (*Panthera onca*) and mountain lions (*Puma concolor*).

<table>
<thead>
<tr>
<th>Farm Name</th>
<th>Year</th>
<th>Livestock</th>
<th>Total</th>
<th>Losses to Felids</th>
<th>% Losses to Felids</th>
</tr>
</thead>
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<td>Cattle</td>
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<td>2.50</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>2,099</td>
<td>8</td>
<td>0.38</td>
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</tbody>
</table>

Table 4. Cattle losses on an annual basis, considering only farms that actually had cattle losses, represented bin number of head.

<table>
<thead>
<tr>
<th>Farm Name</th>
<th>Year</th>
<th>Livestock</th>
<th>Total</th>
<th>Losses Lion</th>
<th>Losses Other</th>
<th>% Losses Lion</th>
<th>% Losses Other</th>
</tr>
</thead>
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<td>Cattle</td>
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<td>1</td>
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<td>Cattle</td>
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<td>6</td>
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losses below average (14.28%). Keeping vulnerable livestock penned at night may help avoid losses. Mountain lions usually attack livestock at night, and are wary to come close to human habitation. Sunquist and Sunquist (1989) commented that axis deer (*Axis axis*) gather around houses at night in order to minimize attacks from predators.

Hornocker (1987:183) recommends dealing with livestock losses to mountain lions "on individual case basis than a continuing blanket effort aimed against all... Various herding strategies and use of guard dogs with livestock have shown some promising results in preventing heavy losses". In our study we attempted to record information on the influence of dogs in preventing attacks. Because dogs usually stay at the main house and livestock are usually elsewhere in the visited farms, we have only sparse information on the influence of dogs in preventing attacks. The keeper of Dona Olindina has three dogs, and says the eldest can keep mountain lions away from the sheep. The sheep are kept beside the main house and losses are zero. The farm Potreiro Velho also keep the sheep beside the main house, and show small losses. At this farm the mountain lion attacked at night and killed a pig and a sheep while the two dogs kept barking.

**SUMMARY**

Cattle losses to mountain lions are not frequent. All farms that had losses to attacks had grazing cattle in vulnerable areas, yet not all farms that kept them vulnerable suffered losses to attacks. What causes mountain lions to attack cattle in only few farms are still unknown. However, we were able to compare sheep losses on farms that kept them in a pen overnight near the main house and those that didn't. Farms that adopted this simple management technique had less than 3% of sheep loss to mountain lions. Other farms, with 2 exceptions, had above 14% losses, averaging 34.51% losses to mountain lions. We should keep in mind that this is not a profile of all farms from the study area, but a profile of those farms that suffer attacks from mountain lions. Goat losses were high, and occurred at all studied farms that had goat herds. Goats were raised extensively on studied farms. Swine losses have no patterns. Some of the losses to other causes may be due to mountain lion attacks. Swines grazed extensively and amount to the smallest investment on farms compared to other livestock.

Mountain lions usually attack livestock at night, and with rainy or drizzle weather. Winter and Spring are the seasons with most mountain lion attacks.

**ACKNOWLEDGMENTS**

We like to thank the people of the Department of Ecossistems at IBAMA-Santa Catarina, specially biologists Américo Ribeiro Tunes and Marlise Becker, for redirecting the calls of mountain lion incidents, and for their continuous support. IBAMA partially funded the trips to check incidents.

**LITERATURE CITED**


ASSESSING SUBSPECIES STATUS:
A HOLISTIC EVALUATION OF THE YUMA MOUNTAIN LION

Donald E. McIvor. Department of Fisheries and Wildlife, Utah State University, Logan, Utah 84322-5210

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Key words: Arizona, California, Cougar, *Puma concolor browni*, Morphology, Mountain Lion, Subspecies Status, Taxonomy.

Abstract Recent consideration of the Yuma mountain lion as a potential Threatened or Endangered species prompted us to examine the evidence supporting this population's designation as a subspecies. We took a holistic approach, examining taxonomic and ecological data and all published references to the subspecies. Currently available data casts the subspecific status into doubt. Existing data are inadequate for a rigorous morphometric comparison between this and surrounding populations, but we conclude C.H. Merriam's original basis for designating the Yuma mountain lion as a subspecies was incorrect.

The Colorado Desert puma (*Felis azteca browni*), was described on the basis of one specimen collected 19.3 km south of Yuma, Arizona (Merriam 1903). Subsequent taxonomic revision assigned this population to *F. concolor browni* (Young and Goldman 1946), and more recently to the genus *Puma* (Wilson and Reeder 1993). Merriam (1903) considered the animal to be smaller in skull morphology, particularly dentition, and paler and grayer in coat color than *P. c. azteca*, the adjacent subspecies occupying central and eastern Arizona. Merriam (1903) also believed the skull morphology of the specimen conferred adaptation to the desert environment, including a preference for smaller prey and a hunting strategy relying more on sight than hearing.

Several published accounts building on Merriam's (1903) work delineated and expanded the range of *F.c. browni* Grinnell (1914) conducted a biological survey on the Lower Colorado River (LCR) between 15 February-15 May, 1910. His range map for *F.c. browni* was based on sighting reports and 2 specimens donated to his party (Grinnell et al. 1937). Young and Goldman (1946) published the only major revision of *F. concolor* taxonomy, in which they expanded the range of *F.c. browni* beyond that suggested previously. Their evaluation also appears to be the first to have incorporated all 9 cataloged specimens. The most recently published range map indicated the widest range yet reported for *F. c. browni* (Duke et al. 1987). The reported range described a parabola extending south from Lake Meade, Nevada, expanding to encompass the LCR and the territory between Calexico, California, and Lukeville, Arizona.

Recent literature on mountain lion ecology casts doubt on the taxonomic status of *P. c. browni*. Questions surround the ability of the extant prey base in *P. c. browni*’s range to support an independent, self sustaining mountain lion population (Shaw 1989). Also, the documented ability of mountain lions to disperse and the apparent lack of barriers to also located specimens collected in the historic range of *P. c. browni* and gathered morphometric skull measurements dispersal suggests *P.c. browni* may be freely exchanging genetic material with adjacent mountain lion populations (Shaw 1993). Although no random population sample has been drawn from *P. c. browni* range, evidence indicates few females (McIvor et al. 1994); hence reproduction in the area may be low or even non-existent (Peirce and Cashman 1993), lending support to the hypothesis that the region may be populated by mountain lions dispersing into marginal habitat from surrounding populations. Habitat degradation, particularly along the LCR corridor (Weaver 1982, Williams and Kilburn 1984, Shaw 1989, Hansen 1992), has likely reduced the region's ability to support a mountain lion population. Subsequently, the original indigenous population may have been driven to extinction, to be replaced by occasional mountain lions moving through the area from surrounding higher quality habitat.

Recent publications have suggested an integrated approach involving natural history (including range and distribution), morphology, and molecular genetic data should be used to assess subspecific status (Ryder 1986, Avise 1989, O'Brien and Mayr 1991, Cronin 1993). We evaluated *P. c. browni* based on the suite of existing data, and suggest additional data needs to fully determine the status of this population.

METHODS

We evaluated the status of the Yuma mountain lion based on the current state of knowledge of desert-dwelling mountain lions. We examined >270 articles in the published literature and conducted interviews with >70 wildlife biologists and public land managers to determine whether available data support *P. c. browni*’s subspecific status. We collected reports of mountain lion sightings, signs, and kills in the published range of *P. c. browni* as an indication of whether the area supports a mountain lion population. We (McIvor et al. 1994). We used the morphometric data to perform a canonical variate analysis (CVA) (Reyment et al.
1984) to address whether available morphometric data supported a taxonomic distinction for this population, and to assess the accuracy of Merriam's original claim that *P. c. browni* could be distinguished from conspecifics on the basis of tooth size.

**RESULTS AND DISCUSSION**

For clarity, we will consider the 3 lines of evidence (ecology, morphology, genetics) separately for the Yuma mountain lion, and then provide a conclusion synthesizing all 3 sources of information.

**Ecology**

We located 6 published range maps for this subspecies (McIvor et al. 1995); no consensus exists regarding the probable range of *P. c. browni*. Only the maps of Hall (1991) and Young and Goldman (1946) appeared to coincide, and Hall (1981) cited Young and Goldman (1946) as his source of information for *P. concolor*. We found that none of the authors satisfactorily explained the derivation of their maps, thus there was little basis for choosing one over another. We elected to use Duke et al.’s (1987) map because it encompasses the largest geographic area, and thus represents the most parsimonious approach to conserving biological diversity.

Personal interviews and requests for information, as well as our review of the literature, produced 272 sighting reports of mountain lions within *P. c. browni*'s published range. Of these reports 142 could not be confirmed, 17 were reports of specimens, and the remaining 113 reports were categorized as confirmed (McIvor et al. 1994). The densest grouping (43.8%) of sighting accounts occurred in the vicinity of Ajo and Organ Pipe National Monument (OPNM), Arizona. This clustering is an artifact of OPNM’s systematic record keeping, the efforts of B. Broyles (pers. commun) to collect sighting accounts in the area of Cabeza Prieta National Wildlife Refuge, and the movement of mountain lions in the Ajo and Sauceda Ranges outside the eastern boundary of *P. c. browni*'s range. The remaining accounts were scattered fairly uniformly across the range described by Duke et al. (1987).

Interpretation of sighting reports and their implications is problematic (Van Dyke and Brocke 1987). Mountain lions appear to be seen with modest frequency throughout the study area, however, the frequency of sightings decreases as the core range (the area around Yuma) is approached. The distribution of sightings, particularly near OPNM, and the home range data collected by Peirce and Cashman (1993), indicate that the range boundaries delineated for *P. c. browni* have no biological relevance, and in many areas do not correspond to any isolating geographic barriers.

Merriam (1903), based on his perception that the teeth of *P. c. browni* are smaller than those of conspecifics, hypothesized that the Yuma mountain lion subsisted on smaller prey than other subspecies. The larger body of literature documenting the importance of deer in the diet suggests that mountain lions in North America are dependant on some form of large prey for long-term population maintenance (Anderson 1983, Shaw et al. 1988). A study conducted on the eastern boundary of *P. c. browni* range also found deer to be the most frequently occurring prey item in mountain lion diets (Cashman et al. 1992). Finally, the food requirements of females with young (Ackerman 1982, Weaver 1982, Ackerman et al. 1986) suggests breeding populations of mountain lions may not be able to exist in the absence of large prey (Ackerman et al. 1984).

**Morphometry**

We located 17 specimens (10 M, 4 F, 3 unknown). Nine were officially cataloged in museums and 6 specimens were held in private collections (McIvor et al. 1994). Contact with museums revealed an additional animal collected from the Hualapai Mountains of Arizona, as well as a specimen collected on the Kofa National Wildlife Refuge in 1944 (Halloran 1946), that had not been cataloged as specimens of this subspecies.

Partly because opinion varies between researchers regarding the important characters to measure, complete data for all skulls were not available from the literature (Table 1). Some skulls were incomplete, usually because of damage inflicted during collection, and dynamic terminology also contributed ambiguity to some measurements (e.g., "braincase height" and "greatest depth" were used interchangeably).

Early analysis of mountain lion skulls and variation in pelage were based on subjective criteria. Powerful statistical tools are a relatively recent development unavailable to early taxonomists. CVA generates n-1 uncorrelated linear combinations of variables that maximize separation among a priori designated groupings (Bookstein et al. 1985). These variates, which are linear combinations of the original variables, provide a useful framework for displaying the magnitude of the interrelationship between the populations, and can be plotted and studied on a two dimensional graph (Reyment et al. 1984). Furthermore, each component (i.e., original variable) is assessed for its contribution to the separation between populations. CVA has the advantages of being easy to interpret, and only one statistical test is conducted, avoiding the ambiguities associated with a multiple test approach and protected alpha levels. However, CVA is highly sensitive to heterecedasticity, and to sparse data; a single missing variable results in the loss...
Table 1. Morphological measurements (mm) of mountain lion skulls collected within the range of the Yuma mountain lion, *Puma concolor browni*. Measurements were compiled from Grinnell et al. (1937), Hoffmeister (1986), Duke et al. (1987); collection by the authors (specimen 9.4176 and DC); or were provided by museums holding the collection.

<table>
<thead>
<tr>
<th>Specimen number</th>
<th>Location</th>
<th>Sex</th>
<th>Greatest length</th>
<th>Condylar breadth</th>
<th>Zygomatic breadth</th>
<th>Basilar length</th>
<th>Palatine length</th>
<th>Palate width</th>
<th>Maxillai breadth</th>
<th>Posterior process breadth</th>
<th>Braincase height</th>
<th>Branum width</th>
<th>Nasal length</th>
<th>Maxillary teeth: alveolar length</th>
<th>Maxillary teeth: crown length</th>
<th>Upper carnassials: crown length</th>
<th>Upper carnassials: crown length</th>
<th>Lower carnassials: crown length</th>
<th>Mandible breadth</th>
<th>Mandible depth</th>
<th>Upper canine: anterior-posterior</th>
<th>Posterior diameter</th>
<th>Lower jaw: greatest length</th>
<th>Nasal width</th>
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<td>M</td>
<td>172.3</td>
<td>156.2</td>
<td>112.3</td>
<td>159.7</td>
<td>62.0</td>
<td>61.9(^b)</td>
<td>72.2</td>
<td>43.1</td>
<td>71.8</td>
<td>30.9</td>
<td>50.8</td>
<td>49.0</td>
<td>43.7</td>
<td>22.6(^b)</td>
<td>12.2</td>
<td>18.3</td>
<td>49.7</td>
<td>15.1</td>
<td>--</td>
<td>108.7</td>
<td>27.4(^b)</td>
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<tr>
<td>46912</td>
<td>MVZ(^b)</td>
<td>F</td>
<td>189.0</td>
<td>173.0</td>
<td>126.2</td>
<td>146.0</td>
<td>67.7</td>
<td>63.8(^b)</td>
<td>77.4</td>
<td>68.5</td>
<td>68.6</td>
<td>38.4</td>
<td>51.5</td>
<td>40.5</td>
<td>67.2</td>
<td>20.6</td>
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<td>11.3</td>
<td>11.1</td>
<td>123.0</td>
<td>304(^b)</td>
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<tr>
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<td>M</td>
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<td>--</td>
<td>--</td>
<td>77.0</td>
<td>68.3(^b)</td>
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<td>--</td>
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<td>43.5</td>
<td>56.0</td>
<td>48.0</td>
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<td>178.0</td>
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<td>161.0</td>
<td>76.0</td>
<td>65.7(^b)</td>
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<td>61.0</td>
<td>74.0</td>
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<td>45.8</td>
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<td>130.0</td>
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<tr>
<td>DC</td>
<td>--(^c)</td>
<td>M</td>
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<td>59.2</td>
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<td>22185</td>
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<td>205.3</td>
<td>187.2</td>
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<td>81.5(^b)</td>
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<td>15.1</td>
<td>--</td>
<td>139.4</td>
<td>35.7(^a)</td>
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</table>

\(^a\)Museum of Northern Arizona (MNAZ), Museum of Vertebrate Zoology (MVZ), U.S. National Museum (USNM), and the Carnegie Museum (CM).

\(^b\)We attribute the discrepancies between these figures and others for the same parameter to our technique for collecting measurements.

\(^c\)Private collection
of all of the data for a particular specimen. We found that the small sample size and the sparseness of the data would not support a CVA of the complete skull morphometry data set. However, we did analyze the morphometric data relative to 5 tooth measurements (upper carnassial crown length and width, lower carnassial crown length, upper canine anterior-posterior, and maxillary teeth alveolar length). We found that none of the 4 adjacent subspecies of mountain lions, including P. c. browni, could be distinguished on the basis of dentition (Fig.1).

Although morphometrics have traditionally constituted an important tool in distinguishing among species and subspecies, a variety of intrinsic characteristics suggest morphometric data are inherently ambiguous in addressing variation, particularly at the subspecies or population level. Both sexual dimorphism (Gay and Best 1995) and morphometric variation based on age (Gay and Best in press) are documented in mountain lions. Partitioning data according to these factors can reduce overall sample size, which is problematic in populations like P. c. browni, where very few specimens exist. Historically, one of the more egregious errors committed by taxonomists has been to describe populations based on a sample (sometimes as little as a single specimen) inadequate to describe the extent of morphometric variation within a population (Engstrom et al. 1994). Furthermore, historic approaches to describing populations have used discordant features to distinguish among populations, which only tends to increase the ambiguity of the subspecies category. More recent trends in evolutionary biology have suggested a focus on geographic clines in individual concordant features (Avise and Ball 1990, O’Brien and Mayr 1991), and the functional pertinence of these characters relative to their contribution to the survival and reproduction of the organism (Wilson 1992, 1994).

Recent studies have also demonstrated that phenotype is highly plastic in some species, and this plasticity appears to be linked to diet and habitat quality. For example, a relationship between habitat quality and body size has been described for black bears (Ursus americanus) (McCutchen 1993); Stringham 1990, in Craighead et al. (1995) reported a correlation between weight and skull length in grizzly bears (Ursus arctos); and phenotypic plasticity has been offered as one hypothesis to explain geographic variation in raccoons (Procyon lotor) (Mugaas and Seidensticker 1993). Rearing environment also appears to influence the development of some morphological traits in birds (James 1983). Therefore, some morphometric characteristics may be limitations imposed on an animal by its environment rather than adaptations to the environment on the part of the organism, and these morphometric features may respond to changes in habitat quality on a short temporal scale. This suggests that phenotypic variation does not necessarily reflect genotypic variation, and that phenotypic characters may converge or diverge between populations independent of true phylogenetic relationships (Geist 1991). The degree of true plasticity in mountain lion phenotypes has not been assessed.

**Genetics**

An exploration of genetic diversity among mountain lions fell beyond the logistic and fiscal capabilities of our research. However, ongoing research at the National Cancer Institute is examining genetic diversity in North and South American mountain lions, and addressing the subspecific status of P. c. browni (Steve O’Brien and Melanie Culver, Genetics Section, Laboratory of Viral Carcinogens, Frederick, MD, pers. commun.). Preliminary results indicate little genetic variation in North American mountain lions in general; results specific to P. c. browni should be available concomitantly with the publication of these proceedings.

Researchers have used mitochondrial DNA (mtDNA) to examine genetic variation at the fine scale appropriate to the level of subspecies. MtDNA is inherited maternally, and the rate of evolution in mtDNA is generally 5-10x greater than in nuclear DNA, thus it tends to be highly polymorphic within species (Hedrick and Miller 1992). However, it is worth recognizing some of the limitations of mtDNA data, including the fact that it represents a very limited part of the gene pool of populations, and that it infers nothing about adaptive differences between populations (Cronin 1993). As with morphological analysis, the use of mtDNA to assess genetic differences requires a sample size adequate to describe the range of variation within populations. Obtaining a representative sample from across the range of a population, particularly one as sparsely distributed and as cryptic as the mountain lions within the range of P. c. browni can be expensive and problematic. A lengthier discussion of the limitations of mtDNA as an indicator of population status can be found in Cronin (1993).

**CONCLUSIONS**

Weighting and incorporating the 3 types of data we have discussed remains a subjective process. Cronin (1993) proposed that conclusive evidence in any single category should be sufficient to suggest a population might be uniquely adapted to its locale, and to manage the population accordingly. Certainly the most parsimonious approach would be to evaluate situations on a case-by-case basis and to manage the preservation of unique adaptations. As O’Brien and Mayr (1991: 1188) suggested: "The possibility
that a subspecies carries (ecologically relevant) adaptations couples with the potential to become a unique new species are compelling reasons for affording them protection against extinction."

Because the Endangered Species Act requires the conservation of subspecies, we recognize the constraints that the law imposes on wildlife and land managers. However, among widely dispersing mammals which do not appear to be separated by geographic barriers the subspecies category may be either too ambiguous or simply inappropriate as a management designation. From a standpoint of conservation biology, using the mountain lion as an umbrella species with consideration for habitat continuity and connectivity may be a more useful management strategy.

The question of taxonomic status, cast into doubt by ecological evidence, may only be resolved through the examination of a larger morphometric data set, and through the application of modern genetic and statistical techniques. It is unlikely that any single ecological, morphological, or genetics-based approach will or should answer the question of subspecific status.

ACKNOWLEDGMENTS

The Department of Defense (DOD) Legacy Resource Management Program administered by Southwest Division Naval Facilities Engineering Command (SDNFEC), Natural Resources Branch, generously provided funding. We are grateful to W. Fisher for his interest, help, and advice. Many individuals gave generously of their time and information, particularly L. Thompson-Olais, M. Peirce, B. Broyles, L. Haynes, L. Lesika, R. Lidicker, D. Schlitter, and H. Shaw. Thanks to D. Hewitt for his exsanguinated comments.

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THE STATUS OF MOUNTAIN LIONS IN TEXAS

William B. Russ. Texas Parks and Wildlife Department, Box 112, Sanderson, Texas 79848

Key words: Texas, Mountain Lion, Puma concolor, Status, Distribution, Population

The mountain lion is legally classified as a nongame mammal in Texas and is managed within the broad scope of wildlife regulatory authority delegated to the Texas Parks and Wildlife Department by state statutes. This status has been unchanged since 1975.

The Lone Star Chapter of the Sierra Club filed a petition in December, 1991 to place the mountain lion on the list of threatened nongame wildlife. The Department, in response to this request, sponsored and conducted a Mountain Lion Roundtable at Del Rio, Texas in April, 1992 to assess population status and public interest. A set of goals was established for future lion management. The Texas Parks and Wildlife Commission then formally considered the Sierra Club's request at a public hearing in May 1992, but took no action to change the status because no biological information was presented that would support a change in status at that time.

The history of lion management in Texas has been one of large scale population control by livestock producers. Ranchers have attempted to eradicate mountain lions from livestock production areas through both organized government control programs and their own opportunistic efforts. However, since about 1970, there has been a marked change in land-use patterns in areas where lion populations seem to be highest. Large tracts of land have been purchased by individuals and governmental agencies for recreational use. Mountain lion control efforts have been reduced or have ceased altogether on many of these tracts. However, livestock producers continue intensive removal activities.

The Department is currently collecting mortality and sighting data by ecological region to determine the current distribution and population status of Texas lions. Data compiled by Mabie (1983) documented lion sightings into the early 1980's. This information, based on records of department personnel and other sources, revealed a large distribution for the mountain lion. The majority of the sightings occurred in the Trans-Pecos Region with increasing reports in the South Texas Plains and the Edwards Plateau.

POPULATION STATUS

Data on lion mortality and sighting reports were recorded and divided into 10 ecological regions based on topographic, climatic, and edaphic factors, as well as plant community similarities (Gould 1969; Figure 1). These regions include the (1) Pineywoods, (2) Gulf Prairies and Marshes, (3) Post Oak Savannah, (4) Blackland Prairies, (5) Cross Timbers and Prairies, (6) South Texas Plains, (7) Edwards Plateau, (8) Rolling Plains, (9) High Plains, and (10) Trans-Pecos Mountains and Basins. Each mortality or sighting was plotted on a Texas county map. Several counties extend into 2 or more ecological regions; therefore, accurate county locations are critical in locating the sighting or mortality in the correct ecological region.

A statewide survey of mountain lion mortalities and sightings was conducted by Wildlife and Law Enforcement Division personnel from January 1, 1983 through May 31, 1989 (Russ 1989) and combined with mortality and sighting reports by ecological regions from June 1989 through December 1995 (Table 1, Table 2). Many reports were received from the U.S. Department of Agriculture Animal Damage Control personnel, landowners, and the general public in addition to Texas Parks and Wildlife Department personnel. Mortalities were verified and sighting reports were either validated by field visit or corroborated through contact with observers before they were accepted as valid by the Department. Information was collected on time of day the lion was sighted, descriptions of animal, distance, habitat type, activity, and other questions related to the observer's familiarity with wildlife.

A total of 1,726 mountain lion mortalities was recorded for the 13- year period from 1983 to 1995 in 60 Texas counties and lion mortalities exceeded 100 animals each year since 1984 (Table 1). Reported mortalities were about 2.5 times more numerous in 1995 than in 1983. The Trans-Pecos Ecological Region ranked first in mortalities with 73 percent of the total. The Edwards Plateau Ecological Region was second with 18 percent, and the South Texas Plains Ecological Region was third with 8 percent of the total. Less than 2 percent of the total mortalities were reported in the remaining ecological regions where no mortalities were reported. This Texas Parks and Wildlife survey reported the first confirmed lion mortalities for the Pineywoods Ecological Region.

Mountain lions were taken in only three ecological regions in 1995 (Table 3). Animal damage control personnel and private hunters, usually paid by landowners, took 102 lions from across the State with 74 percent from the Trans-Pecos Ecological Region and 26 percent from the Edwards Plateau. Lions were also taken by landowners, sport hunters, Texas Parks and Wildlife Department personnel, and accidents...
ECOLOGICAL AREAS OF TEXAS

1. PINEWOODS
2. GULF PRAIRIES AND MARSHES
3. POST OAK SAVANNAH
4. BLACKLAND PRAIRIES
5. CROSS TIMBERS AND PRAIRIES
6. SOUTH TEXAS PLAINS
7. EDWARDS PLATEAU
8. ROLLING PLAINS
9. HIGH PLAINS
10. TRANS-PECOS, MOUNTAINS AND BASINS

Fig. 1. The Ecological areas of Texas based on Gould's 1969 vegetational areas.
Table 1. Thirteen years of Texas mountain lion mortalities by ecological region, 1983-1995.

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Table 2. Thirteen years of Texas mountain lion sightings by ecological region, 1983-1995.

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A total of 1,679 mountain lion sightings was recorded for 1983 through 1995 in 195 of 254 Texas counties (Table 2). The Trans-Pecos Ecological Region ranked first in total sightings with 30 percent of the total. The Edwards Plateau and South Texas Plains ecological regions were second and third with 23 percent and 20 percent of the total sightings, respectively. The Cross Timbers and Prairies had 9 percent of the total, with 5 percent for the Post Oak Savannah and 4 percent for the Rolling Plains and Pineywoods. The Gulf Prairies and Marshes had 3 percent. This survey recorded the first confirmed lion sightings by Texas Parks and Wildlife Department personnel for the Pineywoods (63 sightings) and High Plains (10 sightings). Verified mountain lion sightings were recorded in all 10 ecological regions of Texas.

Table 3. Cause and number of 1995 Texas mountain lion mortalities by ecological region.
### Mortality Cause

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<th>Mortality Cause</th>
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</table>

East Texas, comprised primarily of the Pineywoods and Post Oak Savannah ecological regions, has become a focal point concerning the status of Texas lions. The first Pineywoods sighting in modern times was recorded in 1990 and had increased to 28 sightings in 15 counties by 1995. Three lion mortalities were recorded in this region since 1990. The Post Oak Savannah had single sightings recorded in 1983 and in 1984. Sightings had increased to 25 in 12 Post Oak Savannah counties by 1995. Juvenile lion sightings also increased dramatically with 10 sightings in the two regions between 1992 and 1995. Mountain lions seem to be extending their range in the eastern regions of Texas.

Department data indicates the present distribution of the mountain lion in Texas is nearly statewide. Stable populations occur in the west, central, and southern portion of the state with the range extending eastward. As discussed above, mountain lion mortalities or sightings were recorded in all the ecological regions. However, data are not sufficient to make a reliable statewide population estimate. It should be noted that some lions seen or killed in the outlying part of the identified distribution in Texas may arise from animals which have escaped from captivity or been transported and released by private citizens. These factors must be considered in validating all reports.

### MANAGEMENT AND RESEARCH

Mountain lion management in Texas addresses a wide spectrum of issues including their impact on domestic livestock, wildlife and encounters with humans. Confirmed lion property damage has been documented in most Texas lion range. Most property damage involves livestock such as sheep, goats, and cattle, but domestic pets (dogs and cats) are also killed by lions. Their role as a major predator on large game animals is of special concern to landowners desiring the enhancement of wildlife populations. Lion predation on a recently reintroduced desert bighorn sheep population on the Black Gap Wildlife Management Area has been documented as the major source of mortality (M. Pittman, Tex. Parks and Wildl. Dept., pers. commun.). Seven out of the 20 bighorn sheep were killed by lions in a 5-month period. This level of predation is an example of small populations prevented from increasing to sustainable numbers. Two documented attacks on humans in Texas occurred in Big Bend National Park by sub-adult lions.

Mountain lions are a prized trophy when taken by sportsmen with a total of 26 lions harvested during 1995 in three ecological regions of Texas. Lions can also become a lifetime memory when observed in the wild by a wildlife enthusiast. Analysis should be developed to assess the recreational value of mountain lions. Mountain lions fulfill an important ecological role as one of the largest predators in the state.

Texas has a widely distributed mountain lion population. Although Texas lion numbers appear stable, research on population levels, recruitment, survival, age structure, and reproduction rate is being collected in west and south Texas. This information will be used to address the future management needs of this species.

### LITERATURE CITED


PHOTOGRAPHIC RECORDING OF MOUNTAIN LION TRACKS

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Key words: California, Mountain Lion, Photography, *Puma concolor*, Tracks

Track count methodology for mountain lion (*Puma concolor*) has been under development in California since the 1970's (Koford 1978, Kutilek et al. 1983, Fitzhugh and Gorenzel 1985, Smallwood and Fitzhugh 1995). One of the methodological problems has been the recording of tracks along the transect for the purposes of identifying and cataloging individuals based on track measurements (Smallwood and Fitzhugh 1993). The problems include recording error and time required to record the tracks. The method of tracing tracks onto acetate sheets (Panwar 1979) forces the investigator onto his/her hands and knees for up to an hour per track set. This method is prone to mixing of dust, sweat, fatigue, and parallax through the glass plate. At least four tracks per rear foot (tracks of rear feet are most often the only available) need to be recorded for reasonable variance estimates. During the last two years we developed photographic methods for recording tracks on snow and dust substrates.

Grigione focused on recording tracks on snow, which were made by known radio-collared mountain lions near the Owen's Valley, California. Smallwood focused on recording tracks from dust along dirt roads throughout California during his statewide mountain lion track counts (Smallwood 1994, Smallwood and Fitzhugh 1995). He switched to photography at the beginning of the 1995 track count, and also photographed tracks made by black bear (*Ursus americanus*), bobcat (*Felis rufus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and badger (*Taxidea taxus*). Thus, we draw on a broad background of track-recording experience and field conditions to describe the benefits and problems encountered when using photography to collect track data.

PHOTOGRAPHY

In the snow Grigione used a 35 mm Nikon SLR camera with manual focus and automatic aperture. She used asa 100 color slide film, and shot the photos from a tripod. Filters, flashes, and umbrellas were used in various combinations to enhance or diminish the natural light. The tracks varied in depth of depression below the surrounding snow surface, and therefore the lighting conditions varied considerably. Each photo included a ruler and a square inch wood block for scale.

During the first several weeks of the 1995 statewide track count, Smallwood used a Minolta SRT201 body with a 70-210 mm variable lens and a lens hood. During the last several weeks he used a Minolta X-700 body with a Minolta 1:3.5, 50 mm macro lens, which had a built-in lens hood. Throughout the track count he used 35 mm asa 100 color slide film from Seattle Filmworks. Smallwood usually carried a photographic umbrella to provide uniform light conditions, despite tree overhangs. However, he usually over-exposed the photos by turning the f-stop 2 "clicks" beyond the recommended exposure provided by the light meter when using a manual camera, as per the advise of a professional photographer. The light meter of manual cameras needs to be respected when using a photographic umbrella.

The first two rolls of film made during the track count included some photos that were blurred by hand movement of the 70-210 mm variable lens while shooting. Once this problem was realized, more care was taken not to move the camera. The best photos were made with the X-700 body and the macro lens. This camera-lens combination was easy to use and produced more clear, flat photos. Focus and exposure were automatic. Smallwood took about 1000 photos of tracks throughout the track count, including those of other mammalian carnivores, and only two or three photos will pose problems in interpretation. Most of the rest were excellent, and will be easy to trace for GIS application (described below). Simple camera arrangements prevent mistakes and malfunctions.

We searched track sets in both directions along roads for the clearest tracks and the safest road conditions, where vehicle traffic might pose a hazard. We placed a metric ruler for scale next to each track to be photographed, as well as a small piece of thin cardboard showing species, date, transect name, and distance from the start of the transect. The same piece of cardboard was used for all the photographed tracks along a track set. The cardboard was always placed just outside the boundary of the track.

Most photos were of a single track each, although pairs of tracks were included within the same photo when they were close together. Pairs of tracks often were photographed together for black bear, and sometimes for mountain lion, bobcat, raccoon, and coyote. More tracks were sometimes included within each frame for striped skunk and other small-bodied carnivores with short stride lengths. However, the goal for each shot was to get as much track detail as possible throughout the picture frame. The photos were best taken from a kneeling position.
PHOTO TRANSLATION

Our original goal was to digitize the tracks recorded in photos, and then make a multitude of shape and size measurements using Arc/Info GIS. Initially, slides were scanned into Adobe Photoshop, in which the level of contrast, clarity and color of each track could be manipulated. Aldus Freehand was then used to outline certain areas of the track which were not clear. However, the majority of tracks were either good or bad and did not benefit from enhancement with either software. In addition, Adobe Photoshop was unable to distinguish between granules of soil and snow on and off the track.

A simpler and more practical approach was developed to translate the photographed tracks into data suitable for Arc/Info GIS. The slides were projected onto a wall so the track outline, other track detail and the ruler could be enlarged and traced onto paper. The projected track size was adjusted so that each track tracing filled about 1/4 to 1/3 of an 8.5 x 11 sheet of paper. The tracings provided very clear borders that could be scanned into Arc/Info GIS and then digitized. Once digitized as Arc/Info coverages, the scale will be assigned according to the ruler tracings. Then measurements of polygon areas will be queried and the data downloaded for statistical analysis.

The use of Arc/Info GIS to make track measurements is worthwhile due to its ability to measure shape and area of polygons that represent toe and heel pads, but it is time consuming. Even after one takes the several weeks needed to learn the program, both digitizing each track and then having the computer make measurements requires many commands and time. The programmer we worked with suggested using ArcScan, which scans and digitizes simultaneously, to import each track into the computer and then develop a program which automates the measurements needed on each track. As an alternative to GIS, both area and linear measurements can be made by hand after tracing the outline of each track from a slide projector. This simpler approach should be more fully developed in lieu of more practical GIS methods.

CONCLUSIONS

We were very satisfied with the photographic method developed thus far. It recorded the necessary track detail from a variety of substrates, including rocky and rough soils off the road. Only sandy soils and melting snow posed problems for photo-recording, albeit these conditions would also challenge the previous methods. Compared to the previous method of tracing tracks onto acetate sheets, the field time of photography was reduced to from 1 hr to 5 min per track set, much of the recording error was eliminated, and the majority of the photos effectively recorded the detail of each track. The field time is replaced, however, by time at the slide projector and GIS workstation. Photography also introduces additional danger of data loss due to mistakes during film development or loading and unloading from the camera. Photographic methods for recording tracks need further development to improve reliability and practicality. For example, tracing the outlines of tracks might be more practical from over-sized black and white prints than from slides.

ACKNOWLEDGMENTS

We thank Vernon Bleich for providing access to his study site and data, the Institute for Sustainable Development and the University of California for funding, and Virginia Smallwood for the use of her camera. We also thank Paul Grant, Mike Johnson, Lee Fitzugh, and Christine Schonewald for technical assistance, and Douglas Padley and an anonymous reviewer for valuable comments on a previous draft of the manuscript.

LITERATURE CITED


THE FORT HUACHUCA-CANELO HILLS TRACK COUNT:
A MODEL FOR VOLUNTEER BASED MOUNTAIN LION MONITORING

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Key words: Fort Huachuca, Huachuca Mountains, Canelo Hills, Track Counts, Puma concolor, Mountain Lion, Wildlife Corridors

Abstract We present the results of an ongoing volunteer-based track count project which monitors the presence of mountain lion (Puma concolor azteca) on the Fort Huachuca Military Reservation in the Huachuca Mountains of southeastern Arizona, and more recently, possible lion movement corridors through the neighboring Canelo Hills. The Fort Huachuca track count has been conducted yearly since 1989. Five routes that cover 15.3 miles (providing a sampling rate of about one mile of route per 2.3 square miles of lion habitat) are monitored twice during a two week period in early June. The track count has been successful in documenting the presence of lions, with an average track per route mile ratio of about 0.24. The track count in the Huachuca Mountains raised a number of questions about possible wildlife corridors to the neighboring mountain ranges and, starting in August 1995, the track count program was expanded to evaluate the inter-mountain movement of lions. Initially, we have concentrated on possible corridors through the Canelo Hills, which lie to the west of the Huachucas and form a natural link to the Santa Rita and Whetstone mountains. Using the same track count method that has proved successful on Fort Huachuca, this program has been conducted monthly between August 1995 and April 1996. Over this time period more than 110 volunteers have participated in the program and more than 60 miles of routes have been covered. While this project is still in its infancy, lion presence has been documented along a number of routes, suggesting that the method may be a useful tool for evaluating the inter-mountain movement of lions. In addition to an analysis of the collected data, we also discuss the important social and educational role served by the track counts.

Track counts can be used to document species presence and, under ideal conditions, to monitor trends in population size and composition. Since 1989, track counts have been used to monitor the presence of mountain lions (Puma concolor azteca) on the Fort Huachuca Military Reserve in the Huachuca Mountains of southeastern Arizona. An important aspect of the track count is the use of citizen volunteers to aid in the surveys. Recently, the track count has been expanded in an attempt to monitor wildlife corridors between the Huachuca Mountains and neighboring mountain ranges through the Canelo Hills. While these track counts have been successful in terms of collecting data, they also provided a valuable forum for the discussion of conservation and lion related issues, and have functioned as an important public outreach and education process, thereby fostering an appreciation and understanding of mountain lions and mountain lion habitat.

Here we describe our track count method, logistics, and results of the Fort Huachuca-Canelo Hills track count. We note that the conclusions drawn from the data collected necessarily are preliminary and acknowledge that, at the present, the social and educational function of the track counts is perhaps of greater relevance and importance.

TRACK COUNT OBJECTIVES AND METHODS

The optimal goals of a track count can include the estimation of actual animal numbers, and the monitoring of trends in relative numbers, population composition and movement or changes in distribution. The realization of these objectives, particularly with a volunteer-based informal track count is problematic. Thus, the primary goals of the Fort Huachuca-Canelo Hill Track Count are more modest and include: 1) development and refinement of the track count method, particularly with respect to the use of citizen-based volunteers; 2) establishment of a large data base which, over a long period of time, may provide valuable information of changes in lion numbers; 3) evaluation of the applicability of the track count method for identifying intermountain wildlife corridors; 4) training of a cadre of citizen volunteers who are qualified to apply the track count method to other areas as the need arises; 5) organization of an annual forum for the discussion of conservation topics and provide an opportunity for networking among the individuals participating in the track counts; and 6) facilitate and promote public education on
mountain lions, the flora and fauna of mountain lion habitat, and conservation issues in the Fort Huachuca-Canelo Hills region.

A standard method has been developed and is applied to all the track counts on Fort Huachuca and Canelo Hills. The routes are covered early in the morning, soon after sunrise, in order to avoid the midday heat and to take advantage of the low-angle morning sunlight. Direct, bright overhead lighting renders the already-faint tracks almost invisible. Routes are not prepared (e.g., dragged) prior to the survey. In the absence of rain, a fine dust layer typically forms on the routes, providing an ideal tracking surface. Based on the results of repeating the route surveys during the Fort Huachuca track count, we have found that tracks typically persist as long as a week in dry weather and, ideally, the track counts are conducted after several days of no rain. Tracks and sign of lions, bobcats, coati, and bears are recorded. High-quality tracks are recorded on a glass plate and transferred to paper. Ideally, one front and one rear track are traced. A set of standard track measurements are made and recorded for each track. When possible, stride measurements are also made. As discussed below, continued quality control problems with the tracings have lead to the additional procedure of photographing the tracks. Recently, the positional location of the tracks are recorded with a hand-held Trimble GPS unit and transferred to a topographic map for spatial analysis. In the case of lions, an attempt has been made to classify tracks according to sex and age but, with the exception of tracks made by mature males or of tracks that are obviously too small to have been made by an adult lion, this information is very uncertain.

FORT HUAUCHUA

The Fort Huachuca Track Counts began in 1989 as an extension of a larger reconnaissance of lion sign conducted by the Arizona Game and Fish Department (AGFD). A team of AGFD employees including Harley Shaw, Norm Woolsey, Jim Wegge, and Ron Day, surveyed lion sign density in a variety of habitats across the state (Shaw et al. 1988). Since 1989, the track count has been conducted yearly on the Fort Huachuca Military Reserve (FHMR) in southeastern Arizona. The count started as a cooperative effort between the FHMR wildlife management personnel and the Research Branch of the AGFD. After the initial two years, the counts were conducted by volunteers cooperating with personnel at FHMR. At present, a number of groups are involved with the track count, including: General Wildlife Services, Chino Valley, Arizona; The Phoenix Zoo, Phoenix Arizona; Keeping Track, Inc., Vermont; and The Sky Island Alliance, Tucson, Arizona.

The study area covered by the Fort Huachuca track count is shown in Figure 1. Five routes (labeled A-E) covering 15.3 miles of route are located in the elevation range between 5000 and 6500 feet along the northeast face of the Huachuca Mountains, within FHMR. All of the routes lie within the encinal vegetation zone described by Wallmo (1955), which includes the oak woodland, woodland chaparral, chaparral with conifer, and pine-oak woodland habitats. These habitats likely support high deer densities, and probably constitute most of the hunting area for lions. From these habitats, lions can easily move upward to cliffs and brushy ledges to bed sites. It is likely that lions spend more time in these areas than in the lower elevations on the FHMR. Because the Fort Huachuca track count has been an evolving, informal reconnaissance rather than a formal survey, the number and length of routes used in the effort has changed over the years (Table 1). The five routes shown in Figure 1 were established as the principal surveying routes in 1994. The five routes were not selected on the basis of any established process (e.g., randomization). Rather, they were selected for characteristics that facilitate track counts, including relatively good substrate for seeing tracks, avoidance of excessively steep terrain and, based upon earlier counts, a history of track presence. The routes are surveyed by separate teams starting at opposite ends of the route, thus requiring each team to cover less than 2 miles in one direction during each survey.

It should be noted that the lion habitat encompassed by FHMR probably does not constitute a full home range for even one lion. The tracks and sign documented during the track count are not sign of animals living full-time within the FHMR boundaries, but rather animals that use the FHMR for a portion of their range but also spend some percentage of their time on surrounding areas. While it is difficult to make an exact measure of the available lion habitat of the FHMR, approximately 35 mi² of chaparral, woodland, and forest habitat exist above the 5000-foot level, which likely constitutes the bulk of the lion habitat. Thus we estimate that an average of 2 to 4 adult lions are located on the FHMR on any given day, based upon densities of lions found in other studies, and assuming that lions socially regulate their numbers as suggested by Hornocker (1970). These would not necessarily be the same lions at any given time, but would instead result from perhaps 6-8 adult lions ranging into home areas that use both peripheral areas and portions of the FHMR. A much greater area of lion habitat exists outside the FHMR boundaries on the Huachuca Mountains than occurs within these boundaries.

The track count information collected since 1989 is summarized in Table 1. Between 1989 and 1993, routes were run only once during the survey period. Beginning in 1994, routes were covered twice with an interval between 3 and 5 days. Track densities varied considerably over the 6 years of
Figure 1. Study area and survey routes in the Fort Huachuca and Canelo Hills.
Table 1. Results of the Fort Huachuca track count, Fort Huachuca, Arizona, 1989-1995.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Routes</th>
<th>Miles</th>
<th>Total No. of Tracks</th>
<th>Tracks per Mile</th>
<th>Mean Tracks per Mile</th>
<th>Male Lion Tracks</th>
<th>Other Lion Tracks</th>
<th>Male: Other Ratio</th>
<th>Number of Scrapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>6</td>
<td>24</td>
<td>11</td>
<td>0.46</td>
<td>0.46</td>
<td>1</td>
<td>10</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>1990</td>
<td>6</td>
<td>24</td>
<td>4</td>
<td>0.16</td>
<td>0.31</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>1991</td>
<td>6</td>
<td>24</td>
<td>5</td>
<td>0.21</td>
<td>0.28</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1993</td>
<td>6</td>
<td>20</td>
<td>2</td>
<td>0.10</td>
<td>0.24</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1994</td>
<td>5</td>
<td>15.3</td>
<td>7</td>
<td>0.26, 0.46</td>
<td>0.25, 0.27</td>
<td>1, 4</td>
<td>4, 3</td>
<td>0.25, 1.33</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(12)*</td>
<td>(0.78)*</td>
<td>(0.32)*</td>
<td>(5)*</td>
<td>(7)*</td>
<td>(0.75)*</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>5</td>
<td>15.3</td>
<td>7</td>
<td>0.46, 0.52</td>
<td>0.28, 0.30</td>
<td>4, 2</td>
<td>3, 6</td>
<td>1.33, 0.33</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(15)*</td>
<td>(0.98)*</td>
<td>(0.40)*</td>
<td>(6)*</td>
<td>(9)*</td>
<td>(0.75)*</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>122.6</td>
<td>34, 37</td>
<td>0.28, 0.30</td>
<td>0.28, 0.30</td>
<td>6, 6</td>
<td>27, 26</td>
<td>0.22, 0.23</td>
<td>19</td>
</tr>
</tbody>
</table>

*Total of both runs.

Table 2. Results of the Canelo Hills track count, Canelo Hills, Arizona, 1995-1996.

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Routes</th>
<th>Miles</th>
<th>Lions Tracks</th>
<th>Bobcat Tracks</th>
<th>Bear Tracks</th>
<th>No. of Participants</th>
<th>Conditions*</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 1995</td>
<td>5</td>
<td>10.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>September 1995</td>
<td>4</td>
<td>8.1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>18</td>
<td>C</td>
</tr>
<tr>
<td>October 1995</td>
<td>4</td>
<td>8.1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>17</td>
<td>A</td>
</tr>
<tr>
<td>November 1995</td>
<td>8</td>
<td>13.2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>24</td>
<td>B</td>
</tr>
<tr>
<td>December 1995</td>
<td>1</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>C</td>
</tr>
<tr>
<td>January 1996</td>
<td>4</td>
<td>6.2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>13</td>
<td>A</td>
</tr>
<tr>
<td>February 1996</td>
<td>3</td>
<td>9.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>C</td>
</tr>
<tr>
<td>March 1996</td>
<td>3</td>
<td>6.2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>62.9</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>111</td>
<td></td>
</tr>
</tbody>
</table>

* A=Excellent, B=Moderate, C=Weathered Out

survey (Table 1), but the average track density recorded is similar to results from other areas considered to be good lion habitat in Arizona (Shaw et al., 1988). The low count for 1993 was attributed to poor tracking conditions due to adverse weather conditions, primarily rain. At the present time, the principal results of the track count can be summarized as follows: 1) the track count consistently is able to record the presence of lions; 2) we find that a sampling rate of 1 mile of survey route per 1.5 to 2.3 mi² of habitat consistently results in the recording of lion tracks. While these estimates are crude at best, they provide an estimate of the sampling rate needed to detect presence of lions in areas where the lion densities are thought to be relatively high (based on our own assessments); 3) over the six years of the track count a running average of about 0.28 tracks per mile of route seems to be robust. This corresponds to an estimated lion density in the range of approximately 1 adult lion per 10 to 20 mi² of habitat. We note however, at this time we have no true measure of this density for the area. In the future, changes in the yearly track density with respect to this running average may provide information about short-term changes; 4) there has been an increase in the ratio of male tracks to other (immature male or female) lion tracks recorded since 1994. The years of 1990, 1991 and 1993 yielded no tracks determined to be from mature males. In contrast, the increase in tracks for the second count in 1994 and for both counts in 1995 (see Table 1), was due to tracks classified as those of mature males. While the early counts appear to be low in males, the cumulative total gives a ratio that is, perhaps, consistent with ratios that have been observed in other populations; and 5)
there appears to be a correlation between the number of scrapes and the number of male tracks recorded, providing support for the notion that more males have been using the study area during the last two years of the track count. The increased scratching activity could indicate a higher proportion of young males vying for home areas, possibly a result of the removal of one or two established resident males from the area during the winter of 1993-1994.

The value of making a second survey of the routes, based on the results listed in Table 1, is uncertain. Because care was taken only to record tracks deposited since the first survey, the accumulation period for the second survey is less than five days. It is difficult to constrain the accumulation for the first survey, but it is likely less than a week, with the exception of tracks in mud which were observed to persist for several weeks. As indicated in Table 1, the number of tracks recorded during the first and second run were similar. Thus, it might be more productive to survey additional routes instead of repeating the track count along the base routes. We note, however, that while the total number of tracks recorded in 1994 were similar for the first and second surveys, more male tracks were recorded during the second survey.

Many more years of data need to be collected on the Fort Huachuca track count before our interpretation of the data can be realistically considered to be meaningful. In the meantime, an important aspect of the Track Count is the increasing number of volunteer participants (39 in 1995), which provides an excellent forum for the discussion of lion issues, the study of local flora and fauna, and networking among the participants. The Fort Huachuca track count has also facilitated important spinoffs, including the formation of Keeping Track, Inc., The Juniper Institute, and the Canelo Hills track count.

**CANELO HILLS TRACK COUNT**

Starting in August 1995, the Fort Huachuca track count was expanded to identify potential corridors between the Huachuca Mountains and the neighboring mountain ranges used by lions and other large carnivores. We speculate that the Huachuca Mountains fall within the home ranges of several lions, and that there is movement by lions between the Huachuca Mountains and neighboring ranges. Each of the four closest mountain ranges to the Huachuca Mountains are within the possible range of an adult lion: the Santa Rita Mountains (with about 47 mi² of lion habitat) lie 27 miles northwest; the Whetstones (with 22 mi² of habitat) lie 15 miles north; 17 miles to the east and across the San Pedro River lie the Mule Mountains (with 23 mi² of habitat); and 22 miles to the west are the Patagonia Mountains (with 8 mi² of habitat). These estimates of lion habitat are based on areas above 5000 feet, which approximately delineate the transition from grasslands to the encinal vegetation zone. We note that even this rough estimate of the amount of lion habitat indicates that no single mountain range contains habitat for a single lion, particularly for males.

The Canelo Hills, a rolling terrain varying in elevation between 4700 and 6000 feet is composed primarily of pinyon-juniper-oak woodlands, may act as a natural conduit between the Huachuca Mountains and the Santa Rita Mountains to the northeast and the Whetstone Mountains to the north (Figure 1). A number of drainages run north-south throughout the Canelo Hills, including Post Creek, O'Donnell Creek, Turkey Creek, and Lyle Creek. Four of the routes (No. 3, 5, 6, 7) follow drainages in the area (Figure 1). The remaining routes are located between the drainages in country which is characterized by wooded mesas. The routes were chosen to transect the study area approximately parallel to the trend of the hills, thereby intersecting the hypothetical corridors passing through the area.

At the present, the Canelo Hills track count (Table 2) is monitoring possible corridors along the western side of the Huachuca Mountains, where development pressures have been light. In the future, we hope to extend the track count to include possible corridors through the more heavily urbanized eastern margin of the Huachuca Mountains where Fort Huachuca and the city of Sierra Vista have impacted the connective links to the San Pedro River Valley and Mule Mountains to the east.

To date fewer lion tracks have been recorded in the Canelo Hills (0.06 tracks per mile of route) compared to the track density recorded on the FHMR in 1995 (0.28 tracks per mile of route). Even when the months of adverse weather are not included in the calculation, the recorded density of tracks (0.12 tracks per mile of route) is less than half that recorded on the FHMR. Additionally the number of bear tracks recorded has been comparable to the number of lion tracks (0.15 tracks per mile of route versus 0.12). We interpret this correlation as evidence that the Canelo Hills corridors are not restricted to use by lions. Lion tracks generally have been recorded in the drainage areas (routes 3, 5, 6 and 7), while the bear tracks have been observed in the interdrainage areas (routes 1 and 2).

The monthly scheduling of the track count has proved to be affected by adverse weather conditions. Poor weather (primarily rain), and associated poor tracking conditions resulted in no tracks being recorded for three of the eight months (September 1995, December 1995, and February 1996), which represents more than a third of the track surveys. As a possible solution to the problem, we plan to conduct the track count quarterly starting in June 1996, surveying the routes only after a week of dry weather. In addition, we plan to repeat the track counts after 3-5 days, following the method employed by the Fort Huachuca track count, to provide a more complete survey of the routes.

Given the short time the Canelo Hills track count has been conducted, the interpretations presented above are...
necessarily preliminary. Perhaps more important than the data collected (especially during the early stages of the project), is the large number of volunteers who have participated in the track count. To date, more than 110 volunteers have participated in the project.

DISCUSSION

In addition to the information provided by the data, the Fort Huachuca and Canelo Hills track counts have helped us to refine the basic method and to identify a number of aspects which can be improved. For example, we have found that routes of 2.5 miles or less make the best survey units. Segments of this length can be covered during the morning hours when light is suitable for seeing tracks. By running a short route out, then returning along it to the starting point, the trackers have the opportunity to search for scratches or other sign on the return run. This approach also simplified logistics, allowing survey teams to simply return to their own vehicles rather than requiring complicated schemes of vehicle exchange or arranging pick-ups. These short runs are not exhausting and allow us to conduct the track count over a long time period. 2) While the tracing of tracks onto glass plates has proved to be an excellent educational exercise, we have found it difficult to control the quality of the tracing, especially when the volunteer turnover rate is high. We will address this problem by photographing the tracks in addition to tracing. 3) Particularly in the case of the Canelo Hills project, the lack of tracks along a route is also valuable information. We have found it important to continually motivate track count participants by conducting pre-count summary of the overall objectives of the project. Care must be taken not to let the desire to see tracks lead to disappointment or distraction from the goals of the project. 4) We have found that there is a need for continual pre-survey training on tracing and identification of tracks.

Perhaps the most important technical aspect of the Fort Huachuca and Canelo Hills projects is the research potential of a long-term database provided by the track counts. While several agencies have used track counts in the past, none have, as yet, stayed with them for an extended period or attempted to improve the technique. All have attempted to use them for trend counts, with varying degrees of success. We recognize the need for any interpretation of such a database to be based on many years of data, most likely more than ten. At this point it is difficult to relate the observed variation in track densities to actual trends in lion numbers. The recent initiation of a radio-collaring lion study in the Huachuca Mountains by AGFD may help us estimate the actual lion densities and provide valuable constraint on the lion densities being recorded in the Huachuca Mountains. In the long term, the data collected will establish a background measure of the average track density in the study area, which can ultimately be used to quantify gross changes in lion numbers, should they occur, or to demonstrate stable populations if no serious change happens. In the short term, such a study does not hold the promise of exciting scientific discovery, however, it will become increasingly valuable over time as indices of historic conditions.

Because the track counts are entirely volunteer-based, these projects have an important advantage of being flexible and serendipitous in nature. These studies are unique in that they are free of pressure form external funding sources to justify results, procedures or the research direction. The studies therefore are at liberty to change objectives, methods, and initiate new studies without the debilitating bureaucratic red tape which plagues so many agency investigations. The Canelo Hills project itself is an excellent example of the advantages of this approach, when questions about the existence of lion corridors between the Huachucas and the neighboring ranges were raised during the Fort Huachuca track count, the flexibility the track count program allowed for the immediate implementation of the Canelo Hills project. In the future, we expect many more, equally fruitful, spin offs from the track counts. In addition, the exclusive use of volunteers for the track counts has yielded valuable information about technical and logistical problems associated with the track count method which can be used to help plan similar studies in other areas.

CONCLUSIONS

The Fort Huachuca-Canelo Hills track counts have demonstrated that a long-term, volunteer-based track count is a viable method for monitoring the presence of mountain lions. Perhaps more important track counts function as an excellent public outreach and education tool which fosters an appreciation and understanding of mountain lions and mountain lion habitat. We have found that a sampling rate of about one mile of route per 2.3 square miles of lion habitat consistently results in the detection of lion tracks, even during the early years of the track count when routes were covered only once. Averaged over the six years of the program, the ratio of tracks per route mile is about 0.30. The participation of an increasing number of volunteers (39 at Fort Huachuca in 1995, and more than 110 during the course of the Canelo Hills project) and various organizations (e.g. The Phoenix Zoo, Keeping Track, Inc, The Sky Island Alliance, Wildlife Damage Review, and The Arizona League of Conservation Voters), underscores the important public education and outreach aspect of the track counts. In the coming years, we hope to further improve the tracking methodology, solve some of the logistical and data management problems we have encountered, and further explore the application of the track count method which has proved successful in the Fort Huachuca-Canelo Hills projects.

LITERATURE CITED


ABSTRACTS
DIURNAL BEDDING HABITAT OF MOUNTAIN LIONS
IN NORTHEAST OREGON

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Ted Craddock. Oregon Department of Fish and Wildlife, 107 20th Street, La Grande, OR 97850, USA.

We initiated an evaluation of diurnal habitat use by mountain lions (*Puma concolor*) in Northeast Oregon. From 1992 to 1994 we completed 61 habitat plots at diurnal bed sites. We compared 32 winter and 29 summer habitat plots with 30 random plots. We described the structural composition of microhabitat features within a 50 meter radius surrounding the lion beds. Five lions were fitted with activity sensing transmitters to determine when a lion was at rest. We used a specially trained hound to document actual bed sites. In winter and summer, lions used forested rimrock for bedding in greater proportion than indicated available by random plots (P<0.05). There were significantly more downed logs present in summer plots than random plots (P<0.05). All habitat plots had either forested rock structure, downed logs, or both. Results suggest that lions need both vertical and horizontal cover components to feel secure enough to bed.

FEASIBILITY OF USING CAPTIVE-RAISED MOUNTAIN LIONS
FOR ESTABLISHING POPULATIONS

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Nineteen mountain lions (*Puma concolor stanleyana*) were released into northern Florida as surrogates for evaluating the feasibility of reintroducing Florida Panthers (*P. c. coryi*) into unoccupied areas of their historic range. These included 11 females and 8 vasectomized males. Six of the released mountain lions were born and raised in captivity at Gillman Paper Company's White Oak Plantation near Yulee, Florida, 10 were captured in the wild in western Texas and translocated to Florida and 3 were captured in the wild in western Texas and held in captivity in Florida for 2-8 years prior to release. Animals were monitored using radio-telemetry at least 3 days/week from 22 February 1993 to 30 June 1995. Fifteen lions established one or more home ranges. Nine (60%) home ranges overlapped one or more other home ranges. This populations was made up of predominately captive-born and wild-caught/captive-held animals in an area that varied in size from 127 to 418 km² (1.5 to 3.1 lions/100 km²). Mountain lions that established home ranges outside of this population had a higher excursion rate than did animals within it. Excursions were more frequent during the breeding season than during the rest of the year. Captive-raised animals tended to establish home ranges more quickly and were more likely to be in association with other animals than were wild-caught animals. However, captive-raised animals, particularly males, were more likely to be seen and caused most of the human/lion interactions that created negative attitudes toward the program. The mean distance from the release site to the home range center and the mean home range size were significantly greater for wild-caught males. Reestablishment of additional Florida panther populations is biologically feasible. It would require incorporating the advantages and planning around the disadvantages of both captive-raised and wild-caught translocated animals. However, it must first be decided whether the tremendous costs involved (economical, political, social, etc.) in the reestablishment of additional Florida panther populations can be offset by the benefits gained in reducing the risk to the present Florida panther population due to random fluctuation.
POPULATION DEMOGRAPHICS OF AN EXPLOITED MOUNTAIN LION POPULATION

Stan C. Cunningham. Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023, USA.

We investigated the population demographics of an exploited mountain lion (*Puma concolor*) population in the Aravaipa-Klondyke Area of southeastern Arizona from February 1991 to September 1993. By comparing mountain lion track surveys on the Aravaipa-Klondyke study area with surveys from around Arizona, we found lion density on our study area was as high as any recorded in the state. Radio-collared mountain lions in our study experienced the lowest overall annual survival rate (0.55) found on any lion study; depredation control was the leading cause of mortality. Male mountain lions were more likely to be killed in depredation cases than females. The sex ratio within our study population was almost even, and mountain lion age structure was similar to that reported in unexploited populations.

PREY AVAILABILITY AND SELECTION BY MOUNTAIN LIONS IN THE ARAVAIPA-KLONDYKE AREA OF ARIZONA

Stan C. Cunningham. Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023, USA.

Prey selection by mountain lions (*Puma concolor*) in the Aravaipa-Klondyke area (2,000 km²) in southeastern Arizona was studied from February 1991 through September 1993. Overall diet from frequency of occurrence as determined from 370 scats was: 48% deer (whitetail and mule deer combined), 34% cattle, 17% javelina, 6% rabbit (cottontail and jackrabbit), 4% rodent, and 2% desert bighorn sheep. Using a correction factor developed by Ackerman et al. 1984, we also estimated percent biomass and proportion of individuals killed. With respect to biomass consumed, cattle was 44%, deer 40%, javelina 10.9%, rabbits 2.9%, and rodents 0.02%. Based on weights of prey consumed, proportion of individuals changes to rabbits 52.7%, deer 16.3%, rodents 12%, javelina 10%, cattle 8%, and desert bighorn 0.5%. Preliminary comparisons with availability as determined from 4 separate 4 day double count helicopter surveys found that lions apparently selected calves (ate more than expected based on availability), killed and ate javelina as expected based on availability, and consumed less deer than expected.

MOUNTAIN LION FOOD HABITS IN A DESERT ENVIRONMENT: PRELIMINARY RESULTS

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From 1985 through 1995 Kenny Logan and Linda Sweanor conducted lion research in the San Andres Mountains of New Mexico. During their field studies the researchers collected one of the largest samples of lion scats and stomach contents ever compiled. In my study each individual scat and stomach is being analyzed for content. Using the results, food habits will be compared between years as well as between seasons. Ultimately, these data along with a kill sample collected over the ten year period will be used to determine possible impacts of lion predation on some prey populations. After analyzing approximately 500 scats and stomach contents I have observed 12 different prey species. Preliminary data shows that mule deer (*Odocoileus hemionus*) is the primary food item throughout the year with several small mammal species varying in importance seasonally. I expect this pattern to hold throughout the analysis of the remaining scats.

DNA FROM MOUNTAIN LION SCAT: PRELIMINARY STUDIES
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Michael Syvanen. Department of Medical Microbiology and Immunology, School of Medicine, University of California, Davis, CA 95616, USA.

Walter Boyce. Department of Pathology, Microbiology, and Immunology, School of Veterinary Medicine, University of California, Davis, CA 95616.

DNA analysis can prove valuable for assessments of mountain lion population size, predator-prey interactions, and lion-human interactions. A three year study to examine several aspects of individual and population genetic structure of mountain lions in California by the use of molecular markers in blood, tissue, and scat (feces) was begun in June 1995. Objectives for the study include the following. First, techniques to extract and analyze DNA mountain lion scat will be developed and validated. Use of genetic markers in scat samples will be evaluated as a method of mark-recapture for population density estimates and for tracking movements of specific individuals. Scat collected at prey kill sites (particularly bighorn sheep) will be tested for both predator and prey DNA. Second, geographical patterns of mountain lion distribution in California will be examined from a genetic perspective. Among populations of special interest are those of the Sierra Nevada and Sonoran Desert regions of Southern California.

Preliminary results of the scat DNA portion of this study will be presented. Fecal and blood or tissue samples were collected from captive animals housed at rehabilitation facilities and from carcasses presented for necropsy. DNA was extracted from fecal samples using a standard phenol-chloroform protocol, then purified using gel filtration columns. Polymerase chain reaction (PCR) technique was used to amplify genetically variable microsatellite regions in DNA extracted from scat, tissue, and blood samples. The results of preliminary research will be presented, comparing the identity and quality of DNA extracted from feces with DNA extracted from tissue of the same individuals. The use of scat DNA for identification of species, gender, and individuals will be discussed. This work will provide a foundation for studies in population genetics, forensics, population demographics, and predator-prey ecology.

TESTING OF 'A RIGOROUS TECHNIQUE FOR IDENTIFYING INDIVIDUAL MOUNTAIN LIONS (Puma concolor) BY THEIR TRACKS'

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In 1993, Smallwood and Fitzhugh introduced a rigorous method to make individual animal identification by tracks more objective than previously possible. Working with nine mountain lions, they were able to correctly group 100% and 92% of the tracks from the left and right rear feet, respectively. While they worked with lions that were geographically separated, the identity of the mountain lions was unknown. In order to refine the "ground truth" the Smallwood-Fitzhugh method, 324 photographs of radio-collared mountain lion tracks were collected during the winter and spring of 1994 in Round Valley, Bishop, California. Tracks were photographed during different times of the day in different soil substrates, including snow. Linear, area, and angle measurements were taken directly from the photographs and subsequently analyzed statistically using Fisher's linear discriminant analysis for more than two groups. Track dimensions were measured both manually and by various computer programs, including ArcInfo geographical information systems. Preliminary results suggest that, based on the three types of measurements, approximately 80% of the track sets correspond with the appropriate radio-collared mountain lion.
PRELIMINARY EVALUATION OF FLORIDA PANTHER GENETIC RESTORATION AND MANAGEMENT

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Eight non-pregnant female Texas cougars (Puma concolor stanleyana) were quarantined and then released at five locations in South Florida from 29 March-26 July 1995 for genetic restoration of the Florida Panther (P. c. coryi) population. Genetic restoration is intended to reduce inbreeding and restore genetic variability and vitality for a healthier, more resilient population of Florida panthers. Management strategies will be developed to maintain genetic diversity that is historically typical of the North American population, and will restore the long-term, adaptive capacity of the panther population. Telemetry and biomedical data were collected on 18 radio-collared Florida panthers and eight female Texas cougars. No significant biomedical or health problems were detected during quarantine. Social interactions have occurred between Texas cougars and both female and male Florida panthers. One litter of intercrossed kittens (F, M) were born in late-September and the second intercrossed litter (F) was born in mid-October. Four female panthers denned during the previous year; seven neonate kittens (3F, 4M) were examined at three dens and five panther kittens were marked with transponders; all intercrossed kittens have been marked with transponders. One Texas cougar was struck and killed by a motor vehicle on 20-21 September; she was found to contain three half-term fetuses upon necropsy. Mortalities of instrumented panthers included three males and two females; two males died from intraspecific aggression, a female died of pleuritis, another female was struck and killed by a vehicle, and the third male's cause of death was unknown. Florida panthers showed spatial use patterns similar to previous years. No displacements of Florida panthers have occurred nor have disruptions to the existing social organization been observed. Movements of Texas cougars were generally within habitat areas used by Florida panthers and the occasional movements in atypical areas such as mangroves and suburban areas were probably typical of animals exploring unfamiliar terrain. Evaluation of genetic restoration of the panther population will be based on the relative demographic and reproductive performance, morphological traits, and genetic characteristics of F1 and F2 intercrossed offspring.

SPATIAL-TEMPORAL ANALYSES OF MOUNTAIN LIONS IN THE SIERRA NEVADA: LOOKING FOR PATTERNS AND "BULLS-EYES" AMID THE MESS

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From 1983-1992, the California Department of Fish & Game and the U.S. Forest Service Pacific Southwest Research Station conducted a telemetry study of mountain lions in the Sierra Nevada to learn more about their habits and impacts on mule deer of the North Kings Deer Herd. Data on thirty animals (11 male, 19 female) were used to examine home range (95% adaptive kernel estimate), elevational change, and spatial-temporal relationships. Over 8,500 radio locations were used in analyses. Mean home range size for males during winter and summer was 139 and 176 sq.mi., respectively. Female home ranges averaged 63 and 117 sq.mi. Most lions moved up/down in elevation seasonally, while some maintained home ranges at low elevations. In summer, lion density over years ranged from 1.2-2.0 lions/100 sq.mi.; during winter, density ranged from 1.4-3.0 lions/100 sq.mi. Spatial overlap was highest among females (mean = 32%), intermediate between the sexes (mean = 31%), and lowest among males (mean = 23%). Overlap of kittens with non-mother adults was also examined. Kitten home ranges overlapped more with adult males in summer (mean = 43%) than with females (mean = 27%). Initial results of spatial-temporal relationships among lions will be presented. As an example, each male overlapped with about 85 percent of males known to be present in summer, and 94 percent of males in winter.
EFFECTS OF COUGAR (Puma concolor) PREDATION ON DESERT BIGHORN SHEEP (Ovis canadensis mexicana) IN THE SAN ANDRES MOUNTAINS, NEW MEXICO

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We quantified the effects of cougar production on a remnant population (range=30-37) of desert bighorn sheep on the San Andres Mountains in southern New Mexico from 1985-1994. At the same time, we intensively studied cougar population dynamics. The finite rate of survival (FRS) for 48 lambs was 0.771. The FRS for 9 radiocollared yearlings was 0.777. Program MICROMORT was used to estimate annual survival rates for 36 radiocollared bighorns (21 ewes, 15 rams) that occupied a 703 km² treatment area where we experimentally removed 760.6% of the independent cougars in 1991. Annual survival rates for ewes and rams combined averaged 0.814 (range=0.639-1.0). Of 21 radiocollared sheep deaths, 8 (0.38) were due to cougar predation and 13 (0.62) were due to other causes. Other causes included falls (4), disease (4), old age (2), unknown (2), and breached birth (1). The mean age of radiocollared sheep killed by cougars was 6.13 years (SD=5.33, range=1-16). Five of 8 sheep killed by cougars had clinical scabies (Psoroptes ovis) and 1 was in poor physical condition. The mean age of sheep that died from other causes was 6.46 years (SD=3.57, range=3-14). Nine of 13 sheep that died of other causes had clinical scabies. Two apparently died from scabies. There was no correlation between cougar predation rates on radiocollared sheep and cougar density on the treatment area (r²=0.022). On the San Andres Mountains, a reduction in cougar density did not cause a corresponding increase in the desert bighorn sheep population.

SURVIVAL AND MORTALITY OF COUGARS (Puma concolor) IN THE SAN ANDRES MOUNTAINS, NEW MEXICO

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We quantified survival and natural mortality in an unhunted cougar population that we studied for 10 years (1985-1995) on the San Andres Mountains (2060 km²) in southern New Mexico. Survival rates of cubs were estimated using the finite rate of survival (FRS) for 211 cubs and the change in the mean number of cubs per litter (CN) in 74 litters. Estimated cub survival rates using the FRS and the CN methods were 0.76 and 0.725, respectively. The sex ratio of cubs that died was 1:1, identical to the observed sex ratio at birth. Natural causes of mortality were from cannibalism (0.44), starvation (0.37), disease (0.11), accidental fall (0.04), and coyote predation (0.04). Twenty-six radiocollared subadults (16 F, 10 M, 7.6-27 months old) had a FRS of 0.88 for females and 0.60 for males. Survival rates of subadult females and males were not significantly different (X²=2.62, 1 df, P=0.11). All 6 of the subadult cougar deaths were due to intraspecific killing. Annual and span survival rates were estimated for 85 radiocollared adult cougars (51 F, 34 M, 18-152 months old) by using program MICROMORT. Adult female annual survival rates averaged 0.811 (range = 0.523-1.0). Adult male annual survival rates averaged 0.905 (range = 0.790-1.0). The 8-year span survival rate for adult males (0.450) was significantly greater (Z=1.724, P=0.04) than the span survival rate for females (0.188). Intraspecific killing was the greatest mortality factor, causing 55% of the deaths in adult females and adult males. Intraspecific killing of adults was not related to cougar density (Z=0.300, P=0.76). Other natural causes of mortality included accidents (22% of female deaths, 0 male deaths), disease (0.01 of female and 0.30 of male deaths), old age (0.06 of female and 0.20 of male deaths) and unknown causes (0.11 of female deaths). Sport-hunting may cause additive mortality in cougar populations.
FEMALE MOUNTAIN LION (*Puma concolor*) HOME RANGES IN THE SOUTHERN SANTA ANA MOUNTAINS, CALIFORNIA

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Eight female mountain lions were radio-collared and monitored between October 1986 and December 1989. Individual mountain lions were monitored for periods from 9 to 38 months. Total home ranges for this period varied from 56.5 km$^2$ to 237.7 km$^2$ ($\bar{x}=111.2$, SD=58.4, n=8). Annual home ranges for five mountain lions for the 1988-89 period varied from 81.7 km$^2$ to 226.3 km$^2$ ($\bar{x}=113.3$, SD=64.9, n=5). The 1988 dry season (April 1-October 31) home ranges ($\bar{x}=64.1$ km$^2$, SD=35.4, n=6) and 1988-89 wet season (November 1-March 31) home ranges ($\bar{x}=68.4$, SD=37.2, n=7) were similar in size ($t=0.213$, 10 df, $P=0.83$). The 1989 dry season home ranges ($\bar{x}=31.6$, SD=9.1, n=6) were smaller than either of the 1988 dry season or 1988-89 wet season home ranges ($t=2.375$, 11 df, $P=0.037$; and $t=2.558$, 11 df, $P=0.025$). The smaller 1989 dry season home ranges were the result of all 6 female mountain lions producing litters during that season and confining their movements to areas near natal dens, whereas in 1988 only 1 female was accompanied by kittens. A core area analysis of total home ranges indicated the female mountain lions did not use distinct core areas during this study. In general home ranges remained stable from year to year; however, urban development may have decreased habitat availability for two mountain lions. The stability of the home ranges may be attributed to the abundance of the resident deer population, and the relatively mild climate.

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MOUNTAIN LION (*Puma concolor*) VOCALIZATIONS IN THE SANTA ANA MOUNTAINS, CALIFORNIA

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Vocalizations of wild and free ranging mountain lions in the Santa Ana Mountains were heard during a five year study of mountain lion ecology. The vocalizations were classified as one of three types: screams and yowls; "ouch" calls; and clicks, whistles, and buzzes. Calls in each of these three categories are indicative of a different type of behavior. Screams and yowls were associated with female estrus cycles and may be considered advertisement calls. "Ouch" calls were heard following unsuccessful hunts and may indicate frustration. Clicks, whistles, and buzzes were given by adult females and their juvenile kittens and are considered contact calls.

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SOCIAL ENCOUNTERS AMONG MOUNTAIN LIONS (*Puma concolor*) IN THE SANTA ANA MOUNTAINS, CALIFORNIA

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The intraspecific encounters of eight female and two male mountain lions were monitored over a three year period. Five male-female and 18 female-female encounters were observed. Encounters lasted from one to six days and involved two to three mountain lions. Yowls and screams were heard during several of these encounters. The encounters of adult females occurred at intervals of 20-22 days and the timing is consistent with the length of estrus cycles in mountain lions. Sixteen of the eighteen encounters among females were females without kittens. Two encounters involving an adult female with kittens were brief and one resulted in a fight. No males were observed on the study area from February 1988 through February 1989. Following the appearance of a male mountain lion in February 1989 all female mountain lions were bred and produced litters during the spring and summer of 1989. No encounters were observed following the production of litters.
The absence of male mountain lions and the subsequent reproductive failure led to a partial breakdown of the mutual avoidance reaction. The mutual avoidance reaction may be a means by which adult female mountain lions protect their young kittens.

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**MOVEMENTS AND DIETS OF MOUNTAIN LIONS IN SOUTHWESTERN ARIZONA**

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Much of Arizona supports a healthy, viable mountain lion (*Puma concolor*) population. However, movements and diets of mountain lions in the desert portions of southwestern Arizona have not been described in detail. The Arizona Game and Fish Department has conducted lion track surveys in the Lower Colorado River Valley Subdivision of the Sonoran Desert habitat (Shaw et al. 1988). Lion tracks were not observed during 22 routes totaling 346 kilometers (215 miles). Mountain lions have been documented (sport, road, and depredation kills) within the Arizona Upland Subdivision of the Sonoran Desert. This subdivision forms a curving border along the northeastern edge of the Sonoran Desert.

We studied mountain lion occurrence, movements, and food habits within a 2,575 square kilometer (1,000 mi²) study area centered 129 kilometers (80 miles) northwest of Phoenix, Arizona. The Sonoran Desert in southwestern Arizona is located within the Basin and Range Geographic Province. This area is characterized by small (often <259 km²), insular mountain ranges separated by broad valley basins.

Five mountain lions were telemetered and monitored between February 1989 and October 1995. Home ranges for 3 of these mountain lions were determined to be 787, 412, and 241 km². These home ranges included intermountain movements between 5 isolated mountain ranges within the study area.

While monitoring these radio-collared mountain lions we collected scats to determine the diet of lions inhabiting this portion of the Sonoran Desert. We identified ≥15 vertebrate items in 159 mountain lion scats. Desert mule deer (*Odocoileus hemionus crooki*) (36%), was the primary food item, followed by collared peccary (*Tayassu tajacu*) (21%), cattle (10%), desert bighorn sheep (*Ovis canadensis mexicana*) (7%), small rodents (6%), lagomorphs (6%), badger (*Taxidea taxus*) (5%), and skunk (*Spilogale* sp. or *Mephitus* sp.) (3%). Our results suggest that mountain lions in the Sonoran Desert may be dependent upon alternative prey which compensates for low ungulate densities. In small populations of bighorn sheep (<100) the level of lion predation we observed may be significant.

Though this was not an intensive study we did invest sufficient effort to question the apparent absence of female mountain lions. We seldom encountered sign from lions other than those we had radio-collared. This is not to say that other lions could pass through without detection but that we question the long term presence of other lions.

This study was conducted as part of the Arizona Game and Fish Department's policy of allowing Wildlife Managers the opportunity to conduct Special Investigations. These studies are performed in addition to normal duties and responsibilities. The success of this effort was not possible without the assistance of many people both inside the Department and volunteers from the public and University of Arizona.
MOUNTAIN LION-HUMAN AND MOUNTAIN LION-LIVESTOCK INCIDENTS IN MONTANA

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We present data on 245 mountain lion incidents reported in Montana between July 1989 and July 1995. Incidents were defined as an interaction between mountain lions and humans or livestock, initiated by the mountain lion, that was perceived serious enough to warrant attention by wildlife agencies. Combined incidents increased from 23/yr to 48/yr throughout the period. There were 123 (50.2%) incidents involving livestock and 122 involving humans. The number of livestock incidents increased regularly from 8 in 1989-90 to 35 in 1994-95. Sheep (67%) were most frequently preyed upon by mountain lions followed in rank by horses, goats, cattle, poultry, llamas, and rabbits. Human incidents were highest in 1991-92 (n=27) and declined steadily to 14 in 1994-95. The peak time period for both livestock and human incidents was between June and November. Age and physical condition of mountain lions killed in control actions is characterized as young (1-4 yr; 61%; 2 yr) and in good condition. There is no difference in either age structure or condition class of lions involved in livestock vs. human incidents. Male mountain lions were involved in significantly more livestock incidents than females, but sex ratios of lions involved in human incidents were not significantly different from 50:50. Livestock incidents occurred in central Montana where sheep production is greatest and in western valleys where there is a greater proportion of hobby ranchers. Human incidents mostly occurred near western intermountain valley communities. A record of the frequency of calls to agencies by people involved in incidents inflates the reporting of actual incidents. We discuss biological, socioeconomic, and policy factors affecting rates of both livestock and human incidents.

DEVELOPING AN ADAPTIVE MANAGEMENT PROGRAM FOR MOUNTAIN LIONS (Puma concolor) IN MONTANA

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We describe research initiated in Montana during 1995 to help reduce the uncertainty associated with decisions concerning mountain lion management in a rapidly changing environment. The American West is experiencing the most massive redistribution of humans since the early land-rush days. Of the 10 US states with the fastest growing human populations, seven are in the West. At the same time, mountain lion populations are reported to be reaching historically high levels in many of these areas. Human-mountain lion interactions are also reported to be increasing and creating difficult choices for people living and working in the region, as well as for agencies responsible for mountain lion management. We use a risk assessment approach that identifies real or objective risks associated with mountain lions and perceived or subjective risks. Both risks have associated benefits and costs to society or management that we are measuring with economic methodology. Socio-economic literature suggests a bimodal distribution of beliefs about such risks, skewed to both over and under estimation of the objective risk. The discrepancy between what the public perceives and those risks that experts believe is scientifically founded creates significant policy dilemmas. Over-estimation of the risk increases management costs. Underestimation may initially lower costs, but creates a potentially volatile whiplash of negative sentiment in the event of low probability-high consequence mountain lion-human interactions. To understand and manage the objective risk, we are comparing distribution and abundance data for mountain lions with variables pertaining habitat, prey, land-use, humans, policy governing mountain lions, and the historical influence of wolves. For the subjective risk, we are using mail and telephone surveys to gain insights into the knowledge, beliefs, attitudes and underlying assumptions of both the public and wildlife professionals about mountain lions. We are also using an economic method of "expressed preference" to estimate the public's acceptance of risk associated with mountain lions. Results will be formulated into conceptual models as well as an objective feedback management function based upon historical data but designed for systematic updating.

MOUNTAIN LION PREDATION ON BIGHORN SHEEP
IN THE PENINSULAR RANGES OF CALIFORNIA

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An investigation of cause-specific mortality among 91 radio collared bighorn sheep was conducted from November 1992 through January 1996 in the Peninsular Ranges of southern California.  Mountain lion predation was the most significant cause of mortality and accounted for 63% (27/43) of all mortalities in the 6 sheep populations included in the study.  Lions accounted for 0-100% of all mortalities within these populations, and 0-27% of the radio collared sheep within any given population were killed by lions annually. The age at capture of the sheep varied significantly among populations, and the age distribution of sheep killed by lions did not appear to differ from this pattern.  Sheep of both sexes were preyed upon by lions but a statistical comparison between sexes was not possible because only a small number of rams were radio collared.  Predation occurred during all times of the year except for the months of June, July, and August.  Sixty-seven percent (18/27) of the predation events occurred between December and March.  It appears that lion predation has been a significant limiting factor during the past three years, and sustained high levels of predation by lions may adversely affect the long-term viability of this threatened metapopulation of bighorn sheep.

ORIENTATION, MOVEMENTS, AND SURVIVAL OF TRANSLOCATED COUGARS IN NEW MEXICO

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We conducted a 2-year study of wild-caught translocated cougars to evaluate translocation as a management tool to: 1) re-establish cougar populations in historic ranges, 2) relieve the threat of inbreeding in isolated populations, and 3) manage nuisance cougars.  Our objectives were to document orientation, movements, establishment, and survival of translocated cougars and to make comparisons with similar parameters for cougars in a reference population. Thirteen cougars were translocated an average of 477 km from the San Andres Mountains (SAM) study area in south-central New Mexico to 9 release sites in northeastern New Mexico and were monitored from 9 December 1990 through 7 January 1993.  A fourteenth cougar was translocated 338 km from the SAM to northwestern New Mexico on 8 April 1989 and monitored to 29 May 1990.  Initial orientation of cougars away from release sites ranged from 22E-313E and were uniformly distributed about a 360E circle.  Eight (4 M:4 F) of 14 cougars had endpoints > 80 km from their release sites and endpoint directions that were almost exclusively south, southwest or southeast (x=181E), suggesting the cougars homed toward the source population.  Two males returned to their original home ranges in the SAM.  Distances moved from release sites to endpoints ranged from 3-285 km for 8 females and 11-494 km for 6 males.  Nine of 14 translocated cougars died during the study.  Annual survival rates for translocated cougars averaged 0.55 for females and 0.44 for males and were lower for both sexes during the second year of the study.  Translocation was most successful with cougars that were 12-27 months of age.  For management or conservation programs, we suggest that 12-27 month-old cougars are the best candidates for translocation.
INTERACTIONS BETWEEN COUGARS AND WOLVES (AND A BEAR OR TWO) IN THE NORTH FORK OF THE FLATHEAD RIVER, MONTANA

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Cougar (*Puma concolor*) populations exist in all areas of the west where wolf (*Canis lupus*) recovery is proposed or currently underway. As wolf recovery efforts continue, agencies responsible for the management of predator species will need information on how predators such as cougars and wolves interact with one another and the combined effect of predation on ungulate species. Since January 1993 we have radio-marked and monitored a total of 39 cougars in and near areas used by 2 established wolf packs. Cougar winter home ranges overlapped to a high degree with wolf winter use areas and ungulate winter ranges. During winter months, we have documented instances of wolves and bears (*Ursus arctos*) tracking and treeing cougars and displacing cougars from ungulate kills. Three cougars have been killed by wolves or bears during the past 3 years of our study. This paper will present preliminary findings of spatial-temporal relations of cougars and wolves, predation on ungulates, and discuss reproductive success and survival of cougars in the North Fork valley.

STUDY AND INTERPRETIVE DESIGN EFFECTS ON MOUNTAIN LION DENSITY ESTIMATES


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Density estimates have been considered essential for sound ecological theory and wildlife management. We therefore synthesized reported mountain lion density estimates and accompanying study attributes to assess their use in management. Habitat and other biological and physical aspects of the study site explained virtually none of the 30-fold range of variation in mountain lion density, nor did sampling methods and other aspects of study and interpretive design. Most (78%) of the variation in mountain lion density estimates can be explained by the spatial extent of study area, but the reason for this relationship remains unknown. Without making adjustments for the effect of spatial scale, mountain lion density estimates cannot be meaningfully compared and extrapolated to larger geographic areas. Field studies would contribute more to our knowledge of mountain lion by spanning larger areas, a greater variety of land uses and habitats, and more of their distributional range. Local detail in mountain lion distribution needs to be connected to the larger extent of their range, with many more studies, sampling methods that are efficient across large areas, and by not just selecting sites where the animals are known to occur.
TEN YEARS OF CALIFORNIA MOUNTAIN LION TRACK SURVEY


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During the summer of 1995 we conducted the fourth statewide mountain lion track survey since 1985. Surveys were conducted in 1985 and 1986 by wildlife biologists from multiple natural resources agencies, mostly from the California Department of Fish and Game. Smallwood surveyed the transects in 1986, 1992, and 1995. Assuming the number of track sets is indicative of the mountain lion population, mountain lions in California decreased in number substantially from the mid 1980's to the 1990's. Regional trends have been dramatic, including alarming declines east of the Sierra Nevada and in southern California. Declines in 1992 were followed by an increase across the northwest part of the state, the central coast, and the Sierra Nevada. The track sets found were clustered within small geographic areas; no tracks were found across the vast majority of the mountain lion range that was sampled during 1992 and 1995. The clusters of track sets changed locations between surveys since the 1980's. Mountain lions traveled along certain aspects of the dirt roads in directions and at locations according to habitat, topographic, and interspecific (prey and competitors) conditions. The mountain lion population can be efficiently monitored across large areas, and it can serve as an indicator of large-scale ecological conditions by further developing track count methodology.

DISPERAL OF COUGARS (*Puma concolor*)
IN METAPOPULATION DYNAMICS

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We intensively studied an unhunted cougar population on the San Andres Mountains (SAM, 2060 km²) in southern New Mexico from 1985-1995. We examined the role of dispersal in order to (1) adequately describe cougar population dynamics and social organization in the SAM, and (2) determine the importance of dispersers to other subpopulations within dispersal distance of the SAM. Characteristics of dispersing cougars, including age, sex and direction and distance traveled were based on 33 radiocollared progeny (20 F, 13 M) and 1 eartagged male born between June 1986 and September 1992. Known age of independence for 12 of these progeny averaged 13.5 months for females (n=6, SD=1.6) and 14.0 months for males (n=6, SD=1.5). Known age at dispersal for 8 progeny averaged 13.6 months for females (n=2, SD=0.9) and 15.7 months for males (n=6, SD=1.4). Twelve of 20 (60%) female progeny did not disperse from their natal areas, whereas all 14 of the male progeny dispersed. One of 20 females and 6-7 of 14 males dispersed outside the SAM. Distances traveled by progeny from the arithmetic center of their natal home range (NAC) to the arithmetic center of their independent home range (IAC) averaged 12.4 km for females (n=19, SD=19.6) and 101.3 km for males (n=7, SD=26.0). Dispersing males traveled by significantly further from their NACs to their IACs than dispersing females (t=2.86, df=13, P=0.007). Dispersal directions from NACs to IACs were uniformly distributed about a 360° circle for both females (n=7, U=0.08, P=0.48) and males (n=8, U=0.06, P=0.05). Recruitment and emigration rates were quantified based on a 5.1 year time span (February 1990 to 23 February 1995) and 114 tagged progeny (63 F, 51 M) out of 137 detected progeny born from 1 February 1988 through 19 November 1992. From 1990-1995, 21 progeny (17 F, 4 M; x̄=4.1/year) and 22 immigrants (8 F:14 M; x̄=4.3/year) were recruited into the adult SAM population. For the same period, we estimated that 47 progeny (26 F, 21 M, x̄=9.2/year) successfully dispersed (i.e. dispersed and reached adulthood) outside the SAM. The majority of female (60%) and male (81%) cubs which are born on the SAM and survive to adulthood apparently disperse outside of the SAM. The SAM cougar population is an important source of immigrants to other cougar populations within dispersal distance of the SAM. The role of dispersal is important to the understanding of cougar metapopulation dynamics and the implementation of regional conservation strategies.
REPRODUCTIVE BIOLOGY OF FEMALE COUGARS (*Puma concolor*)
IN THE SAN ANDRES MOUNTAINS, NEW MEXICO

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As part of an intensive 10 year study of cougar population dynamics, we quantified the reproductive biology of an unhunted cougar population on the San Andres Mountains (2060 km²) in southern New Mexico. From 1986 through 1994 we documented the birth of 220 cubs from 79 litters by 39 females; 174 of the cubs (76%) were subsequently captured and tagged. Mean litter size for 53 litters which were first observed 9-49 days (\(\bar{x} = 32.3, SD = 8.9\)) after birth was 3.02 cubs (range 2-4, SD = 0.7). Twenty-six of the 53 litters were observed at birth nurseries, the other 28 litters were observed at secondary nurseries. For 21 litters first observed from 52-127 days (\(\bar{x} = 175.7, SD = 112.0\)) after birth, litter size was smaller, averaging 2.19 cubs (range = 1-3, SD = 0.8). The sex ratio for cubs from 50 litters observed at 9-49 days (\(\bar{x} = 31.6, SD = 8.6\)) after birth was 73 F:75 M. However in 15 litters first observed at 52-427 days (\(\bar{x} = 198.9, SD = 121.6\)) after birth, a greater number of females were observed (20 F:14 M). The gestation period for 31 litters based on documented matings was 91.5 days (range = 83-103, SD = 4.0). Litters were born during every month except February (\(n = 78\)). The greatest number of litters were born during the months of August and September (\(n = 11\) litters each). Sixty-five litters (83%) were born during the months of May through November. Known age females were on average 21.4 months old (\(n = 7\), range = 19-27, SD = 3.1) when we first documented them in association with male lions. Known age females produced their first litters at 22-40 months of age (\(n = 12\), \(\bar{x} = 29.1\), SD = 6.0). Litter size for first litters (\(n = 8\)) averaged 3.4 cubs and was greater than the average litter size of 3.0 for 22 subsequent litters born by 14 females (\(t = 1.43, df = 28, P = 0.08\)). Thirty-nine of 53 adult-aged females produced from 1-5 litters each. Ten of the reproducing females (26%) produced 110 of the cubs (50%). Interbirth intervals for litters in which at least 1 cub survived to independence (\(n = 14\)) or to 12 months of age (\(n = 1\)) averaged 17.4 months (range = 12.6-22.1, SD = 2.6). On average, 75% of the adult female cougars were raising cubs each year (range = 63-100%, SD = 12.7). It took 5 females an average of 100.0 days (range = 17-308, SD = 118.1) to successfully rebreed after the loss of a litter. Sport-hunting of females may adversely affect a cougar population by killing the most productive females and/or orphaning cubs.

SOCIETAL PREFERENCES FOR MOUNTAIN LION MANAGEMENT ALONG COLORADO'S FRONT RANGE

Harry C. Zinn. Human Dimensions in Natural Resources Unit, College of Natural Resources, Colorado State University, Fort Collins, CO 80523, USA.

Michael J. Manfredo. Human Dimensions in Natural Resources Unit, College of Natural Resources, Colorado State University, Fort Collins, CO 80523, USA.

Jim Jones. Colorado Division of Wildlife, 6060 Broadway, Denver, CO 80216, USA.

Linda Sikorowski. Colorado Division of Wildlife, 6060 Broadway, Denver, CO 80216, USA.

This study examined public attitudes toward mountain lions and mountain lion management along Colorado's Front Range. Three populations were surveyed using mail-back questionnaires during spring of 1995: the Denver Metro area, the Colorado Springs area, and the Foothills area west of Denver. An overall response rate of 58% was obtained. Data were tested for non-response bias and weighted appropriately. A majority of respondents had positive attitudes toward mountain lions and were likely to believe that mountain lions are a sign of a healthy environment and pose little real risk to people living near them. In a test of knowledge of recommended responses to a mountain lion encounter, two out of three people were aware of actions recommended in CDOW educational materials. Two out of three subjects agreed that steps should be taken to control the number of mountain lions coming into Front Range residential areas. Among strategies to control mountain lion populations, public hunting for mountain lions or deer was somewhat more acceptable (40%) than using trained hunters (30% - 40%) or developing sterilization techniques for mountain lions (30%). In response to incidents involving mountain lions in residential areas, monitoring a mountain lion was widely acceptable if a lion had done no harm,
but less acceptable as incidents grew more severe. Capture and relocation was acceptable to a majority in all situations. Frightening a mountain lion away with rubber bullets or fireworks was unacceptable to a majority in all situations. Destroying a mountain lion was highly unacceptable unless a human had been injured or killed. Fifty percent reported that they would accept destroying a lion that had injured a person, and 60% reported that they would accept destroying a lion that had killed a person. Individuals sympathetic to the idea that wildlife should have rights similar to the rights of humans were less likely than others to believe mountain lions pose a real risk to people and less likely to accept hunting or destroying mountain lions. Results demonstrated that, in dealing with mountain lions at the population level, strategies involving public hunting were more acceptable than anticipated. Results also highlighted the importance of continued public education. Public education appears to have increased awareness of how to minimize risk in encounters with mountain lions. Public education may also widen the range of publicly acceptable options available to wildlife managers by clarifying why capture and relocation is not always used.
STATE STATUS REPORTS
ALBERTA

1. What is your goal for management of mountain lion?

   Management Plan for Cougar in Alberta, 1992
   a. Protection from significant decline.
   b. Optimal allocation amongst users.
   c. Provide commercial benefit.
   d. Minimize property damage.
   e. Encourage scientific and education benefits.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?

   Approximately 20 percent, approximately 50,000 square miles.

3. What is your estimated mountain lion population?

   650 to 750.

4. What is the five-year trend in the population size?

   Stable or modest increase.

5. What is your mountain lion depredation policy?

   Compensate and occasionally relocate.

5a. How many depredation incidents occur annually?

   35 per year (approximately 25 for livestock).

5b. How many lions are killed annually because of depredation?

   Approximately four per year.

6. What is your mountain lion public safety policy?

   Capture/kill lions in serious human incidents.

6a. How many public safety incidents related to lions occur annually?

   One to two per year.

6b. How many lions are killed annually for public safety reasons?

   Less than one per year.

7. What management actions do you use to reduce public safety incidents?

   Nothing much. Public safety incidents area rare.
8. How many lions are killed annually by hunters?

   Average 52 per year.

9. What is your annual budget for management of mountain lions?

   1995-96: $33,000 to food habit research; approximately $10,000 for other.

10. Please summarize current and recent mountain lion research activities.

    Support provided to private consultant annually:
    1994-95 - summer activities related to disturbance
    1995-96 - analysis of kills and scats

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

    Renewal of provincial predator compensation is underway.

Report Completed By: John R. Gunson    Telephone: (403) 422-9537
ARIZONA

1. **What is your goal for management of mountain lion?**

   Manage the mountain lion population, its numbers and distribution, as an important part of Arizona's fauna. Provide mountain lion hunting and other related recreational opportunities.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**

   77 percent or 62,000 square miles of Arizona (exclusive of Indian Reservations or National Park Service lands) is occupied mountain lion habitat.

3. **What is your estimated mountain lion population?**

   Arizona's mountain lion population is estimated at 2,500 lions.

4. **What is the five-year trend in the population size?**

   The mountain lion population in Arizona increased slightly from 1990 until about 1992 or 1993 and has decreased slightly in the past two years, probably in response to deer numbers.

5. **What is your mountain lion depredation policy?**

   Arizona’s mountain lion depredation procedures are established in State Law, Arizona Revised Statute 17-302.

5a. **How many depredation incidents occur annually?**

   About 50 incidents have been reported annually for the past five years.

5b. **How many lions are killed annually because of depredation?**

   An average of 31 mountain lions has been taken annually as a result of depredation over the past five years.

6. **What is your mountain lion public safety policy?**

   Arizona does not have an official mountain lion public safety policy and deals with each incident on an individual basis.

6a. **How many public safety incidents related to lions occur annually?**

   In recent years there have been two to five incidents each year which have involved mountain lions in public safety issues at highly variable levels of concern.

6b. **How many lions are killed annually for public safety reasons?**

   In recent years 0-1 mountain lions have been killed per year for public safety concerns.

7. **What management actions do you use to reduce public safety incidents?**

   All management options are utilized to deal with public safety incidents involving mountain lions, including trapping and relocation, euthanasia and sport hunting.
8. How many lions are killed annually by hunters?

An average of 203.4 mountain lions has been taken annually by sport hunters in Arizona over the past five years.

9. What is your annual budget for management of mountain lions?

The Arizona Game and Fish Department does not budget management expenses by species. In fiscal 1995, approximately 2.5 percent of the management budget was utilized for mountain lion management.

10. Please summarize current and recent mountain lion research activities.


Current Research: Genetics of Mountain Lions in Arizona.
Feeding Behavior of Mountain Lions in Arizona.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

No political action concerning mountain lions in Arizona is currently evident.

Report Completed By: John S. Phelps
Telephone: (602) 789-3352
Predator/Furbearer Biologist
Arizona Game and Fish Department
BRITISH COLUMBIA

1. What is your goal for management of mountain lion?

Management goals for cougar are to maintain viable populations over their current range, to provide for recreational hunting opportunities, and to reduce cougar problems through site-specific control, preventative husbandry, and harvest manipulations.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?

About 560,000 square kilometers or 60 percent of B.C. is cougar habitat.

3. What is your estimated mountain lion population?

Estimated cougar population is >4,000, based solely on regional intuition.

4. What is the five-year trend in the population size?

The five year trend in population size is stable or increasing in all management regions with hunttable cougar populations. Sightings and animal control complaints indicate cougar are also established in Regions 6 and 7, but there are insufficient data to allow a hunting season.

5. What is your mountain lion depredation policy?
5a. How many depredation incidents occur annually?
5b. How many lions are killed annually because of depredation?

6. What is your mountain lion public safety policy?
6a. How many public safety incidents related to lions occur annually?
6b. How many lions are killed annually for public safety reasons?

Any cougar which threatens or attacks humans or livestock is to be pursued and killed if possible. Animals are only relocated if they have not caused a problem (usually just passing through and ended up in the wrong place at the wrong time), can be captured without threat of injury to personnel or the cat, and are an adult in good condition. All relocated animals are ear-tagged.

Depredation and human safety incidents cannot be quantified and separated on a provincial basis without recourse to original Conservation Officer Service reports, which are not readily available. On a provincial scale, there are very few actual attacks on people, about one every other year. There are numerous complaints of cougar predation on livestock from all areas with cougar populations. On an annual basis, the total number of cougar killed for Animal Control averages 64 over the last five years and is increasing (31 in 1990 fiscal to 104 in 1994: these figures do not include those animals relocated or complaints where a cougar was not located). Most AC kills take place in Region 1, Vancouver Island.

7. What management actions do you use to reduce public safety incidents?

All Ministry personnel interviewed by the press on the subject of cougar emphasis preventative measures to avoid or survive cougar encounters. Numerous talks to school children are given on cougar and bear safety every year. B.C. Environment, Wildlife Branch has also put out a brochure Safety Guide to Cougars, available at all Ministry of Environment, Ministry of Forests offices, and Government Access Centres.
8. **How many lions are killed annually by hunters?**

Hunter kill varies by region, depending on access, season length, quotas, and snowfall. Six regions with cougar seasons have three different season lengths, with female quotas in two regions, a total harvest quota in one region, and a provincial bag limit of two. The 1990-94 average harvest is 261 with an increasing harvest trend (220 in fiscal 1990 to 336 in fiscal 1994).

9. **What is your annual budget for management of mountain lions?**

There is no single individual with provincial responsibility for cougar management nor any provincial budget other than that expended on data management. Budgets in regional offices are minimal (e.g., the total operational budget in 1995 for cougar, grizzly bear, wold, and black bear management in Region One is $5,000, which does not include funding secured for research). Funding for cougar research varies by region and year according to perceived need and ability to secure funding. Cougar are not a priority compared to grizzly bear. A best estimate of baseline funds targeted at cougar management would be $2,000/region for a total of $12,000. This is primarily associated with the time needed for compulsory inspection of all cougars killed.

10. **Please summarize current and recent mountain lion research activities.**

One study is currently underway on Vancouver Island, determining population density and habitat use in an area of low deer population and extensive second growth forest. There is a second privately funded study ongoing in the East Kootenays, but I have not been able to obtain information on it. At least two more studies, one in an area with relatively more deer and more old growth forest on Vancouver Island, and one in the East Kootenays are proposed. Both will focus on determining population densities.

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

No.

**Report Completed By:** Knut Atkinson
CALIFORNIA

1. What is your goal for management of mountain lion?

Maintain healthy populations.
Minimize conflicts—public safety, depredation and other wildlife.
Protect important habitats.
Recognize ecological role and value.
Monitor populations and conduct research.
Improve public awareness.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?

Approximately 60 percent. 233,571 sq. km of available habitat.

3. What is your estimated mountain lion population?

4,000-6,000.

4. What is the five-year trend in the population size?

No detectable change in population over the last five years from available data. Population can be considered stable.

5. What is your mountain lion depredation policy?
5a. How many depredation incidents occur annually?
5b. How many lions are killed annually because of depredation?

Depredation policy requirements established in Fish and Game Code (Sections 4802-4809):
< Reporting injury to livestock or property
< Confirmation of report by the Department or ADC Officer
< Permit issuance upon verification
  a. permit expires 10 days after issuance
  b. holder of permit shall not begin pursuit more than 1 mile from depredation site
  c. pursuit limited to a 10 mile radius
< Requirement of reporting the capturing, injuring, or killing a mountain lion
< Carcass must be returned to the Department (if feasible)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Permits</th>
<th>Number of Lions Killed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>193</td>
<td>70</td>
</tr>
<tr>
<td>1991</td>
<td>200</td>
<td>73</td>
</tr>
<tr>
<td>1992</td>
<td>193</td>
<td>70</td>
</tr>
<tr>
<td>1993</td>
<td>217</td>
<td>73</td>
</tr>
<tr>
<td>1994</td>
<td>322</td>
<td>122</td>
</tr>
<tr>
<td>1995</td>
<td>330</td>
<td>120*</td>
</tr>
</tbody>
</table>

* Preliminary results
6. **What is your mountain lion public safety policy?**

This policy is generally stated in Fish and Game Code Sections 4801, and provides for the removal of mountain lions perceived as an imminent threat. Detailed guidelines are being developed to assist wardens and safety officers, and include incident command response and coordination.

6a. **How many public safety incidents related to lions occur annually?**

6b. **How many lions are killed annually for public safety reasons?**

Approximately five to ten mountain lions are killed every year in relation to public safety problems. The public reports over 300 sightings/incidents every year to the Department.

7. **What management actions do you use to reduce public safety incidents?**

Management actions to reduce human/lion conflicts; education and information.

8. **How many lions are killed annually by hunters?**

None.

9. **What is your annual budget for management of mountain lions?**

California does not have a management budget for mountain lions.

10. **Please summarize current and recent mountain lion research activities.**

   93-95: Summary and analysis of mountain lion depredation over the last 20 years.
   95: Analysis of mountain lion and human activity in California.

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

   Proposition 197 will be on the March 1996 ballot. It will challenge current legislation (Proposition 117, 1990) designating mountain lions as a "specially protected mammal."

**Report Completed By:** Steven G. Torres  
**Telephone:** (916) 653-7203  
California Department of Fish and Game
1. **What is your goal for management of mountain lion?**
   Recovery of the Florida panther from threat of extinction.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**
   4.5 million acres in south Florida.

3. **What is your estimated mountain lion population?**
   30-50 adult lions on territories.

4. **What is the five-year trend in the population size?**
   Stable to slight decline (?)

5. **What is your mountain lion depredation policy?**
   None.

5a. **How many depredation incidents occur annually?**
   None.

5b. **How many lions are killed annually because of depredation?**
   None.

6. **What is your mountain lion public safety policy?**
   None.

6a. **How many public safety incidents related to lions occur annually?**
   None.

6b. **How many lions are killed annually for public safety reasons?**
   None.

7. **What management actions do you use to reduce public safety incidents?**
   None.

8. **How many lions are killed annually by hunters?**
   Less than one-year.

9. **What is your annual budget for management of mountain lions?**
   $625,000.

10. **Please summarize current and recent mountain lion research activities.**
Genetic restoration, habitat preservation, and population reintroduction.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

No.

Report Completed By: Tom H. Logan, Chief
Bureau of Wildlife Research
Florida Game and Fresh Water Fish Commission

Telephone: (512) 389-4396
IDAHO

1. What is your goal for management of mountain lion?
   Maintain Idaho's mountain lion population; stabilize harvest within 25 percent of 250 (187-313) or three-year running average; and reduce female component of harvest to 25-35 percent.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?
   95 percent. 80,000 square miles.

3. What is your estimated mountain lion population?
   5,000 plus animals.

4. What is the five-year trend in the population size?
   Increasing.

5. What is your mountain lion depredation policy?
   Continue to cooperate with livestock interests and USDA ADC to minimize livestock depredations and document depredations that do occur.

5a. How many depredation incidents occur annually?
   Less than 10.

5b. How many lions are killed annually because of depredation?
   Average of three per year.

6. What is your mountain lion public safety policy?
   No formal policy (written).

6a. How many public safety incidents related to lions occur annually?
   Less than 10.

6b. How many lions are killed annually for public safety reasons?
   Only an occasional lion is killed for public safety reasons.

7. What management actions do you use to reduce public safety incidents?
   Timely response to incidents. Problem animals are removed in the most expedient manner.

8. How many lions are killed annually by hunters?
   1990-94 average is 342 mountain lions.
9. **What is your annual budget for management of mountain lions?**

No dollars specifically budgeted for mountain lion budget other than personnel costs.

10. **Please summarize current and recent mountain lion research activities.**

No current or recent lion research by the state; Idaho State University has been involved in lion research since 1985, documenting population parameters for an exploited population in south-central Idaho.

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

No.

**Report Completed By:** John Beecham  
**Telephone:** (208) 334-2920  
Idaho Department of Fish and Game
1. **What is your goal for management of mountain lion?**

   Long-term perpetuation of viable, healthy mountain lion population that will provide aesthetic and recreational benefits to Montanans and visitors to our state.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**

   Approximately 50 percent of the state or 73,778 square miles.

3. **What is your estimated mountain lion population?**

   We do not have an estimated number for the population.

4. **What is the five-year trend in the population size?**

   The five-year trend in population based on harvest, observation, numbers of chases, depredation and incident reports is upward.

5. **What is your mountain lion depredation policy?**

   Montana is in the process of developing and adopting a policy. We currently assist Animal Damage Control (ADC) as needed.

5a. **How many depredation incidents occur annually?**

   Number of depredation incidents reported between 1990 and 1995 are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Depredation Incidents</th>
<th>Lions Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>08</td>
<td>03</td>
</tr>
<tr>
<td>91</td>
<td>21</td>
<td>04</td>
</tr>
<tr>
<td>92</td>
<td>11</td>
<td>03</td>
</tr>
<tr>
<td>93</td>
<td>15</td>
<td>08</td>
</tr>
<tr>
<td>94</td>
<td>34</td>
<td>03</td>
</tr>
<tr>
<td>95</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

5b. **How many lions are killed annually because of depredation?**

   See 5a. above.

6. **What is your mountain lion public safety policy?**

   This policy is also being developed.
6a. How many public safety incidents related to lions occur annually?

Human/Lion conflicts reported between 1990 and 1995 are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Reports</th>
<th>Lions Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>91</td>
<td>27</td>
<td>08</td>
</tr>
<tr>
<td>92</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td>93</td>
<td>15</td>
<td>08</td>
</tr>
<tr>
<td>94</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

6b. How many lions are killed annually for public safety reasons?

See 6a. above.

7. What management actions do you use to reduce public safety incidents?

Management actions to reduce human/lion conflicts: Hunting is currently the largest management action taken. Any lion felt to be a hazard to the public is currently removed.

8. How many lions are killed annually by hunters?

Mountain lion harvest from 1990 through 1995 follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>227</td>
</tr>
<tr>
<td>91</td>
<td>236</td>
</tr>
<tr>
<td>92</td>
<td>357</td>
</tr>
<tr>
<td>93</td>
<td>424</td>
</tr>
<tr>
<td>94</td>
<td>566</td>
</tr>
<tr>
<td>95</td>
<td>(565 to date, the season closes February 15).</td>
</tr>
</tbody>
</table>

9. What is your annual budget for management of mountain lions?

Montana does not have a management budget for individual species.

10. Please summarize current and recent mountain lion research activities.

Research:

95-97 We are currently conducting a study of predation of bighorns by mountain lions, coyotes, and possibly wolves. To date we have collared five lions and hope to have 10 marked by March 1996.

91-93 A base line study was conducted along the Rocky Mountain Front to determine mountain lion numbers, size of territories, habitat selection, and food habitats.

90-94 Contributed to the funding of studies carried out in Yellowstone Park by the Hornocker Institute.

81-83 Characteristics of a hunted population and the relationships between hunting pressure and population characteristics were studied in an area near Missoula.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

No legislative or initiative actions are currently under way in Montana.

Report Completed By: John J. McCarthy
Telephone: 406) 444-2612
Montana Fish and Wildlife Department
NEVADA

1. **What is your goal for management of mountain lion?**

   Maintain mountain lion distribution in reasonable densities throughout Nevada. Control mountain lions creating a public safety hazard or causing property damage. Provide recreational, educational, and scientific use opportunities of the mountain lion resource. Maintain a balance between mountain lions and prey. Manage mountain lions as a metapopulation.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**

   45 percent, 50,000 square miles.

3. **What is your estimated mountain lion population?**

   2,500 - 4,000.

4. **What is the five-year trend in the population size?**

   Stable to increasing.

5. **What is your mountain lion depredation policy?**

   Under current procedures, a landowner who has loss of livestock may contact the Division of Wildlife or the USDA Animal Damage Control to investigate and confirm the loss was caused by a mountain lion; if so, Animal Damage Control or the landowner under a depredation permit, may pursue and kill the offending mountain lion. Most often when a domestic pet is taken by a mountain lion, deterrent methods are suggested to prevent further loss from the mountain lion. Any person has the right to kill a mountain lion if it has or is about to harm his person or property. The carcass of a mountain lion killed for reasons of depredation becomes the property of the Division of Wildlife.

5a. **How many depredation incidents occur annually?**

   50 to 75 in 1994-95.

5b. **How many lions are killed annually because of depredation?**

   An average of 47 per year from 1990 to 1995.

6. **What is your mountain lion public safety policy?**

   In the past, little emphasis was placed on public safety regarding mountain lions.

6a. **How many public safety incidents related to lions occur annually?**

   Less than five.

6b. **How many lions are killed annually for public safety reasons?**

   Most years none, but no more than two or three annually.
7. **What management actions do you use to reduce public safety incidents?**

Press releases are infrequently developed that provide information to the public on how to reduce the risk of encountering a mountain lion. For the most part, no actions are taken specifically to reduce the occurrence of public safety incidents.

8. **How many lions are killed annually by hunters?**

Average of 161 lions were taken by sport hunters over the previous three harvest seasons.

9. **What is your annual budget for management of mountain lions?**

Approximately $100,000, which includes salary, vehicle use, and operating expenses.

10. **Please summarize current and recent mountain lion research activities.**

Currently, no formal research is being conducted by the Division of Wildlife or other organization in Nevada. The most recent research activity on mountain lions was a study under the direction of California Fish and Game in both California and Nevada along the border in Mineral and Esmeralda Counties; the focus of the study was predation on wild horses.

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

Though there are no legislative or initiative actions undertaken at this time, the Division of Wildlife initiated an internal task force to develop a comprehensive mountain lion management plan for review through a public scoping process and for final approval by the state Wildlife Commission; the plan would provide the Division of Wildlife with a structured and rational approach to all aspects of mountain lion management.

**Report Completed By:** Mike Cox  
**Telephone:** (702) 486-5127
1. What is your goal for management of mountain lion?
   Meet public demand for consumptive and nonconsumptive use.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?
   59 Percent. 70,817 square miles.

3. What is your estimated mountain lion population?
   Unknown.

4. What is the five-year trend in the population size?
   Probably increasing.

5. What is your mountain lion depredation policy?
   Investigate depredation complaints within 24 hours. Destroy offending lion if possible.

5a. How many depredation incidents occur annually?

5b. How many lions are killed annually because of depredation?
   Average four per year 1978-1993.

6. What is your mountain lion public safety policy?
   No official policy.

6a. How many public safety incidents related to lions occur annually?
   Not known, very rare.

6b. How many lions are killed annually for public safety reasons?
   Not known.

7. What management actions do you use to reduce public safety incidents?
   Provide education about lions, advise in the event of an encounter.

8. How many lions are killed annually by hunters?

9. What is your annual budget for management of mountain lions?
   Not distinguished in budget.

10. Please summarize current and recent mountain lion research activities.
Finalize 10 years field study by Hornocker Wildlife Institute with production of ecological monograph by April 1996 and statewide management plan by March 1997.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

No.

Report Completed By: Wally Haussamen  Telephone: (505) 827-9909
New Mexico
Department of Game and Fish
OREGON

1. What is your goal for management of mountain lion?
   To manage for healthy lion populations, incorporating the desires of the public, and statutory obligations of the Department concerning damage to private property.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?
   75 percent with varying densities.

3. What is your estimated mountain lion population?
   3,000 to 3,300 (modeled estimate).

4. What is the five-year trend in the population size?
   Increasing four to five percent a year.

5. What is your mountain lion depredation policy?
   Selective removal and or euthanasia as needed.

5a. How many depredation incidents occur annually?

5b. How many lions are killed annually because of depredation?
   35 in 1994.

6. What is your mountain lion public safety policy?
   Selective removal and or euthanasia as needed.

6a. How many public safety incidents related to lions occur annually?
   289 in 1994.

6b. How many lions are killed annually for public safety reasons?
   Not separated, part of number in question 5.

7. What management actions do you use to reduce public safety incidents?
   Advice to the public, selective removal and/or euthanasia.

8. How many lions are killed annually by hunters?
9. What is your annual budget for management of mountain lions?

Lion management is not a separate budget item.

10. Please summarize current and recent mountain lion research activities.

Two studies (NE and SW Oregon) documenting densities and general life history and demographics.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

1994 Voter initiative banning the use of dogs for lion hunting (Measure 18).
1995 Voter initiative to reverse Measure 18.

Report Completed By: Donald Whittaker Telephone: (503) 872-5260
1. What is your goal for management of mountain lion?

Continue to gain information on lion population status to insure long-term sustainability while providing flexibility for landowner property protection.

2. What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?

Estimated 40 percent. 68,000,000 acres or 106,250 square miles.

3. What is your estimated mountain lion population?

Unknown at this time.

4. What is the five-year trend in the population size?

Sightings and mountain lions have increased.

5. What is your mountain lion depredation policy?

Unprotected nongame. May be hunted legally anytime with a hunting license.

5a. How many depredation incidents occur annually?

In 1992, 84 were reported.

5b. How many lions are killed annually because of depredation?

Approximately 100-130 reported.

6. What is your mountain lion public safety policy?

Do not have one.

6a. How many public safety incidents related to lions occur annually?

Very few reported since 1983 (less than one per year).

6b. How many lions are killed annually for public safety reasons?

Captive lions unknown, few wild lions.

7. What management actions do you use to reduce public safety incidents?

Public education.

8. How many lions are killed annually by hunters?

Approximately 10 percent of total in 1994 (17 reported).
9. **What is your annual budget for management of mountain lions?**

   $16,000 - $40,000 for mountain lion control and selected wildlife management areas.

10. **Please summarize current and recent mountain lion research activities.**

    We have two studies: (1) Ecology and Population Dynamics of Lions on Big Bend Ranch State Park (Trans-Pecos); and (2) Ecology and Population Dynamics of Lions in South Texas (Private Land).

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

    Nothing current. Legislative attempts to place mountain lions in game status have been tried in the past.

**Report Completed By:** Matt Wagner  
**Telephone:** (512) 389-4396  
Nongame Program Leader  
Texas Parks and Wildlife Department
UTAH

1. **What is your goal for management of mountain lion?**

   To manage cougar consistent with prey base, habitat and other biological and sociological constraints to meet the needs of the resource and resource users.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**

   Approximately 60 percent of Utah is considered to be available lion habitat, which provides approximately 41,000 square miles.

3. **What is your estimated mountain lion population?**

   Approximately 2,000 to 3,000.

4. **What is the five-year trend in the population size?**

   Increasing 1990 to 1993, decreasing from 1994 to present.

5. **What is your mountain lion depredation policy?**

   Any lion causing or about to cause damage can be taken by the landowner or their immediate family. The lion is then turned over to the state within 48 hours. We also have a damage compensation policy where up to 50 percent of the market value is paid to the livestock owner for confirmed losses of lambs, ewes, rams, and calves. These monies come from a $50,000 appropriation.

5a. **How many depredation incidents occur annually?**

   150 to 200.

5b. **How many lions are killed annually because of depredation?**

   A ten year average of 36.2.

6. **What is your mountain lion public safety policy?**

   Any lion considered to be a public health and safety risk is removed from that area and released within the same management unit boundaries unless it is considered unsalvageable or a considerable risk to the public.

6a. **How many public safety incidents related to lions occur annually?**

   Five to ten annually over the past six years.

6b. **How many lions are killed annually for public safety reasons?**

   Average of four to five.

7. **What management actions do you use to reduce public safety incidents?**
8. How many lions are killed annually by hunters?

Ten year average 266.8, five year average 332.2.

9. What is your annual budget for management of mountain lions?

$30,000.

10. Please summarize current and recent mountain lion research activities.

We have recently begun a study with Utah State University to research the use of population models to determine cougar numbers in different habitat types. We will be testing several methods in this study which will include track counts, helicopter transect, scent posts. We hope to determine the relative ability of these indices to provide accurate and cost efficient estimators of cougar populations.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

Yes. Representatives are presenting a bill to reduce penalties of illegally taking a lion to a Class B misdemeanor from a Class A. They also want to allow anybody to take a lion that is within a city limit, municipal limit, or housing track of any kind.

Report Completed By: Boyde H. Blackwell
Telephone: (801) 538-4700
Mammals Program Coordinator
WASHINGON

1. **What is your goal for management of mountain lion?**

   Our goal is to preserve, protect and perpetuate mountain lions in Washington. We are mandated to provide a variety of recreational opportunities associated with the public use of cougar, including hunting. The Agency response to mountain lion damage and human safety issues will address the public need, yet be consistent with maintaining the integrity of the mountain lion population.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**

   Approximately 45 percent of Washington's land area is occupied mountain lion habitat. This represents approximately 28,000 square miles.

3. **What is your estimated mountain lion population?**

   Washington currently estimates the mountain lion population at 2,400 to 3,200 animals.

4. **What is the five-year trend in the population size?**

   The population has increased, yet the annual rate of the increase is unknown. The population estimate in 1986 was 1,000 to 1,500 mountain lions.

5. **What is your mountain lion depredation policy?**

   We currently deal with mountain lion depredations under provisions in our Dangerous Wildlife Policy and Procedures. The policy is attached.

   5a. **How many depredation incidents occur annually?**

      During the last ten months of 1995 there were approximately 70 pet and livestock mountain lion depredations reported, and an additional 20 nonfatal attacks on livestock.

   5b. **How many lions are killed annually because of depredation?**

      Approximately 20 lions were killed in 1995 for depredating.

6. **What is your mountain lion public safety policy?**

   See Dangerous Wildlife Policy and Procedures.

   6a. **How many public safety incidents related to lions occur annually?**

6b. **How many lions are killed annually for public safety reasons?**

7. **What management actions do you use to reduce public safety incidents?**

   Public education through Fish and Wildlife Officer and Wildlife Biologist contacts, capture and relocation, capture and rehabilitation, and capture and kill methods are all used at various times to reduce public safety incidents.
8. **How many lions are killed annually by hunters?**

Lion harvest is controlled by permit. Permits have been increased annually, and the kill has followed. In 1993, hunters took 121 mountain lions, in 1994 the kill rose to 177, and in 1995 (results not yet final), 243 lions have been killed by hunters.

9. **What is your annual budget for management of mountain lions?**

The Washington Department of Fish and Wildlife currently spends approximately $125,00/year on mountain lion management. It should be noted that federal ADC/APHIS mountain lion control work in Washington is minimal, and has not been included in this estimate.

10. **Please summarize current and recent mountain lion research activities.**

The WDFW is currently completing a ten year mountain lion research investigation within the Cedar River and Green River watersheds. The study area, located on the west slope of the central Cascades is closed to lion hunting. The significance of mountain lion refuge on surrounding lion populations has been a focal point of the research. The timing, dispersal distance, survival, recruitment and mortality of juvenile and subadult lions has been documented. Resident male and female home ranges have also been determined.

11. **Are there current legislative or initiative actions which would affect mountain lion management in your state/province?**

Yes, the legislature is currently working on passing Senate Bill 6262. This legislation would authorize the Fish and Wildlife Commission to allow a hunter killing a cougar without the use of hounds to purchase a cougar tag after killing a cougar. Initiative 655 (currently in the signature collection process) would prohibit the use of bait to hunt black bear, and would prohibit the use of hounds to hunt black bear, mountain lion, and bobcat.

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**Report Completed By:** Steve Pozzanghera  
**Telephone:** (360) 902-2521
1. **What is your goal for management of mountain lion?**
   
   To maintain healthy, viable populations of lions in all suitable lion habitat.

2. **What percent of your state/province is occupied mountain lion habitat? How many square miles does this represent?**
   
   No estimate available at this time.

3. **What is your estimated mountain lion population?**
   
   We currently have no cost effective method to estimate the number of mountain lions in Wyoming.

4. **What is the five-year trend in the population size?**
   
   Both WGFD personnel and the public are reporting an increase in the number and frequency of mountain lion sightings, and we are receiving more and more complaints from the public regarding the number of lions they are seeing. Lions are being sighted in areas that they have been absent or sparse in the past. Although this may indicate an increasing number of lions within our state, we have no concrete data to support this assumption.

5. **What is your mountain lion depredation policy?**
   
   WGFD provides payment (fair market value) to those landowners/lessees that have incurred losses to property (livestock, etc.) due to trophy game (lions and bears). In addition, Wyoming Statute 23-3 115 states that any bear or mountain lion doing damage to private property may be immediately taken and killed by the owner of the property, employee of the owner or lessee of the property. WGFD is to be notified immediately and all lion carcasses and hides become the property of WGFD.

5a. **How many depredation incidents occur annually?**
   
   WGFD approved an average of 19 claims from 1990-1994, totaling $91,075.77.

5b. **How many lions are killed annually because of depredation?**
   
   One female mountain lion that was depredating livestock was killed in this same five year period.

6. **What is your mountain lion public safety policy?**
   
   Wyoming has no formal public safety policy regarding mountain lions. Anyone who believes they are in danger of being attacked by a lion may defend themselves, but the burden of proof falls on them to prove that it was justified.

6a. **How many public safety incidents related to lions occur annually?**
   
   Public safety incidents involving mountain lions are rare in Wyoming. However, during the 1995 hunting season, an elk hunter near Pinedale was stalked by a male lion while field dressing his animal. The hunter shot and killed this lion. The game warden in the area confirmed the man's story.

6b. **How many lions are killed annually for public safety reasons?**
7. What management actions do you use to reduce public safety incidents?

Removal of problem lions and/or public education efforts.

8. How many lions are killed annually by hunters?

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9. What is your annual budget for management of mountain lions?

$203,160 minimum.

10. Please summarize current and recent mountain lion research activities.

Wyoming currently has no research activities ongoing regarding mountain lions. We do have two lions radio collared that were caught in foot snares targeted at grizzly bears. Relocations are being obtained on these lions during bear flights.

11. Are there current legislative or initiative actions which would affect mountain lion management in your state/province?

None.

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Wildlife Biologists

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