Utah Cougar Management Plan

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INTRODUCTION *by* **Bill Bates**

The cougar (*Puma concolor*), or mountain lion, has been a controversial wildlife species ever since Utah was settled by Europeans in 1847. First legally classified as an 'obnoxious animal' by the Utah Territorial Legislature in 1888, they still cause great concern to many livestock producers in the state. There are many sportsmen who view the cougar as a trophy animal and have sought its legal protection and management. Other hunters view the cougar as a predator that reduces the numbers of mule deer and other big game species. Yet, there is another segment of citizens in the state that view the cougar as a symbol of wilderness, and believe that each cougar has a right to exist without human intervention. No other species elicits the number of divergent opinions at Utah Wildlife Board meetings as does the cougar.

In 1888, the Utah Territorial Legislature passed a bill establishing a five dollar bounty on mountain lions. The cougar did not receive protected status until 1967, when a concerned group of houndsmen petitioned the Utah State Legislature. Legal jurisdiction was given to the Utah Fish and Game Department, which later became the Division of Wildlife Resources. The number of cougar hunters remained fairly constant until the late 1980's. Increased hunter pressure resulted in implementation of a limited-entry permit system statewide in 1990. About the same time, mule deer herds suffered serious declines in the state due to a variety of factors, including severe drought followed by severe winters. Many hunters blamed the cougar for the decline. Biologists became concerned over declining mule deer populations and made recommendations to recover these herds. In response, in 1994, the Utah Wildlife Board implemented a statewide cap on the number of deer hunters. In 1996, the Board passed a policy that allowed the Division to prepare predator management plans to address predation problems in units where big game populations were depressed. Fifteen predator management plans were subsequently approved. In 1997, a harvest objective (quota) management system was instigated on 14 of 30 cougar management units. Harvest levels were also increased in other units.

Controversy over cougar management remained. In 1997, the Division initiated a process to obtain public input on issues and concerns with cougar management. Individuals representing many diverse points of view were invited to form the Cougar Discussion Group. The mission of this group was to aid the Division in preparing a cougar management plan that would hopefully gain agreement from diverse groups. The result, this document, was developed in three segments. Background and introductory chapters were written by members of the Cougar Discussion group. The views of each author are represented in those chapters. This group also identified issues and concerns. Goals, objectives, and strategies were developed by regional managers and biologists of the Division, with input from the Cougar Discussion Group. Individual unit cougar management plans were developed by regional biologists and managers. The final Cougar Management Plan will be presented to Regional Advisory Councils, revised, based on this public input, and eventually passed by the Utah Wildlife Board.

Much of the background information in this plan comes from a study conducted from 1978 to 1989 on the Boulder Mountains in southern Utah, funded by the Utah Division of Wildlife Resources, and carried out by the Cooperative Wildlife Research Units at Utah State University and the University of Wyoming under the direction of Fred Lindzey. The Division is now funding a five-year research project in the southern and western mountains to learn more about cougar population assessment under the direction of Mike Wolfe at Utah State University. Other cougar research continues in northwestern Utah directed by John Laundre at Idaho State University. Information from other cougar studies conducted in the intermountain west was also incorporated.

NATURAL HISTORY *by* **Kirk Robinson**

The cougar is the most wide-ranging land mammal in the Western Hemisphere. From central British Columbia in North America to the Strait of Magellan in South America, its range extends across nearly 110 degrees of latitude. Historically, it also ranged from the Pacific to the Atlantic oceans on both continents. However, due to habitat loss and hunting, it is all but missing east of the Rocky Mountains in North America (Hansen 1992).

Corresponding to the extent of its range is the number of its names: over 80 have been recorded (Barnes 1960). In the western United States it usually goes by 'mountain lion' or 'cougar,' sometimes by 'puma'. In the eastern United States 'catamount' and 'panther' are more common. The accepted scientific name is *Puma concolor* (Wozencraft 1993, Jones et al. 1997).

Of all large felids, or cats, only the cougar still exists in large numbers. In the western United States its numbers have actually increased over the last thirty years or so, following a century of intense persecution (Logan and Sweanor 1998). Most western states believed that cougar populations were increasing or near all time highs in the 1990's (WGFD 1996; J. Seidel, Colorado Div. Of Wildl., pers. comm.; Beecham and Harris 1997; Riley 1998). However, there are indications that cougar populations may be declining in some areas after several years of increased harvest mortality (Bates and Henry 1999). Continued habitat loss is also taking a toll (Hummel *et al.* 1991).

One reason the cougar continues to thrive is its adaptability: it can survive in a wide range of habitat types; from the desert mountains of the southwestern United States, to the dense tropical jungles of Brazil, to the thick forests and snowbound mountains of western Canada, and to the Everglades of Florida (Hansen 1992). It will eat any animal it can kill, including snakes, porcupines, armadillos and grouse, as well as deer, elk, mountain sheep and rabbits, depending on availability (Hansen 1992, Murphy et al. 1993, King and Workman 1985).

Subspecies, Size, Coloration, Longevity, Behavior

Taxonomists recognize at least 10 subspecies of cougar in North America north of Mexico (Goldman 1946, Handley 1981). Of these, at least two, producing among the largest specimens, occur in Utah: *P.c. kaibabensis & P.c. hippolestes* (Goldman 1946, Handley 1981, Durrant 1952, McIvor and Bissonette 1995). Different subspecies are characterized by differentiation in coloration, body size and weight, head size and shape, proportional length of tail, and length of the canines, among other features. No subspecies, except the Florida panther (*P.c. coryi*), is reproductively isolated from all others, and there is constant genetic flow among them. They are capable swimmers and will even swim big rivers.

Adult cougars are fully grown at about three years of age (Anderson 1983), at which time they measure between 6' and 8' from nose tip to tail tip and weigh between 120 and 240 pounds, with a rare few being smaller or larger. The typical adult male is over 7' in length and weigh between 130 and 160 pounds. Adult females average about 90 lbs.

Most cougars are a tawny buff color with either a "red" or a "blue" tint to the coat. The backs of the ears, the tip of the tail and the sides of the muzzle are chocolate brown to black. The chest, belly, cheeks and front muzzle are dull to creamy white. Kittens are born with dark spots and tail rings that fade with time and usually disappear by 12 months of age. The tip of the nose is usually pink and the eyes, blue at birth, soon become amber or green-yellow and have round pupils.

Cougars hunt by stalking their prey, followed by an explosive pounce and a severing of the spinal cord with the canine teeth (Hansen 1992). For short distances they may reach speeds of up to 45 miles per hour. Vertical leaps of up to 18 feet, and horizontal ones over 40 feet, have also been recorded (Spector 1956).

Mountain lions are solitary and elusive creatures, as well as crepuscular, active mainly at twilight and just before dawn (Hansen 1992). For these reasons they are rarely seen in the wild without the aid of specially trained hounds. However, they have on occasion been observed, and, like house cats, can be very playful: kittens will play with each other and with their mothers, and kittens and adults alike will often play enthusiastically with an inanimate object, such as a piece of bark (Grinnell et al. 1937:547, Young 1946:106).

The natural longevity of wild mountain lions is about 12 years (Anderson 1983, Hansen 1992), though occasionally one lives beyond that. Cougar aged 16, 18 and 21 years have been taken during sport harvest in Utah. In captivity they have lived up to 20 years. Even an otherwise healthy lion begins to experience difficulty in killing prey as its canine teeth wear, which begins to become a significant factor after about eight years of age (Hansen 1992, Busch 1996). From then on its chances of survival decline rapidly. Sources of natural mortality are disabilities associated with old age, disease, intra-specific conflict, cannibalism, accidents and starvation (Anderson 1983, Hansen 1992).

Kittenhood to Adulthood

Female cougars generally first mate between 20 and 30 months, with the average in Utah about 23 months (Lindzey et al. 1989, Young 1946, Eaton and Velander 1977, and Logan et al. 1996). After an average 91-92 day gestation period (Anderson 1983, Logan et al. 1996), a litter of one to six kittens are born (Anderson 1983). The average litter size is three (Anderson 1983, Logan et al. 1996), with two or three being most typical (Logan et al. 1996; Lindzey et al. 1989) . The average interval between successive litters is 24 months, with a range from 19 to 40 months (Lindzey et al. 1989). The den is a cave, rock alcove, fallen tree, or dense brush--anywhere that offers protection from the elements and predators, such as coyotes and eagles (Hansen 1992).

While very young, kittens are totally dependent upon their mother. She leaves them at the den while she hunts, returning frequently to attend to them (Anderson 1983). Starting at about three months, as the process of weaning begins, she begins to take them on forays with her and place them near kill sites while she hunts (Shaw 1989). Eventually, they will follow her further afield, observing her in action. At between six and ten months of age they may begin to hunt smaller prey on their own (Anderson 1983). This helps meet the growing energy demands of the family, while at the same time the youngsters learn how to find, stalk and kill suitable prey; lessons essential to their survival. Kittens generally stay with their mothers until 12 to 18 months of age (Hansen 1992). Eventually they leave, probably either because their mother drives them away or because of an innate propensity (Shaw 1989). These subadults, or juveniles, now become transient, often venturing far beyond their natal home range in search of vacant habitat where they can establish their own home range (Hansen 1992, Logan et al. 1996).

Males sub-adults are more likely to leave than females. In an unhunted population in southern Utah, of 14 radio-marked progeny of resident cougar, seven left the study area. Those that remained were female. All the males left (Lindzey et al. 1989). During this period of their lives they are vulnerable to death, for they must not only avoid starvation, but must contend with larger and more experienced resident cougars on whose territories they trespass (Anderson 1983, Hansen 1992, and Logan et al. 1996). Four of the seven juveniles that left the Boulders perished, while all seven that stayed survived (Lindzey et al. 1989). The single greatest cause of mortality to cougars in unhunted populations, especially to juveniles, may be other cougars (Lindzey et al. 1989; Logan et al. 1996), although vehicle induced mortality has been recorded in some areas.

Interestingly, the available evidence suggest that, in areas of human encroachment, transients may be more likely to depredate on livestock (Shaw 1989, Riley and Aune 1996) and to pose a threat to human safety (Beier 1991, Torres et al.1996). As a result, of necessity they may be killed by humans. Equally interesting are the research data indicating that taking "preventive measures" through heavy hunting (as opposed to targeting specific nuisance animals), instead of eliminating potential conflicts, may tend to increase the number of transients, at least in the short run, and therefore the likelihood of conflicts (Shaw 1989, MDFWP 1995). This results from the removal of resident adult males which would otherwise act as a check on the number of inexperienced young transient cougars. To a degree, hunting mortality is compensated for by the decrease in natural mortality that results from a reduction in intra-specific conflict. However, some researchers feel that, especially where hunting is heavy, compensation is only partial (Lindzey et al. 1989).

Adulthood and the Home Range

Juvenile females typically leave their mothers a month or two earlier than males, disperse shorter distances and settle down sooner (Logan et al. 1996). The territory which becomes home to an adult lion is its home range, and the lion which occupies it is a resident. Females will often establish home ranges adjacent to or slightly overlapping their natal home ranges (philopatry), while males will typically disperse much farther, anywhere from 30 to 100 miles, sometimes more (allopatry) (Logan et al. 1996). Rarely, if ever, do lions of either sex begin to breed until they have established a home range of their own (Hornocker 1969, Logan et al. 1996). The period of transience may be a few weeks, or as much as a few years, depending upon a variety of circumstances (Shaw 1989, Weaver et al. 1996). Usually, by the time they are two years old, transient lions have succeeded in establishing their own home ranges (Logan et al. 1996). In unhunted populations, roughly one third of subadult transient lions will not survive to establish home ranges.

Female home ranges average smaller than male home ranges and often overlap slightly, while male home ranges overlap hardly ever (Anderson 1983, Laing 1988, Logan et al. 1996). This arrangement probably serves to minimize competition for prey, and in turn to minimize intra-specific conflict (Logan et al. 1996). Contrary to this, the typical male home range overlaps several female home ranges, which means that a single female home range might be overlapped on disparate parts by several male home ranges (Anderson 1983, Laing 1988, and Logan et al. 1996). This arrangement facilitates breeding and helps ensure genetic mixing (Logan et al. 1996). The size of mountain lion home ranges varies from as small as 10 square miles to as large as 500 square miles, depending on various factors (Hansen 1992). However, home range size is only a partial function of the density of mountain lions. It would be more accurate to say that the density of mountain lions is a function of the size of home ranges. The main determinants of home range size are type of terrain and vegetation, and the availability of suitable prey (Hornocker 1969, Seidensticker et al. 1973, Logan et al. 1985). In combination, these factors set a lower limit on the size of home ranges, and hence, an upper limit on mountain lion density. (Hopkins 1989, Shaw 1989).

Corresponding to the larger size of male home ranges, in unhunted cougar populations, intraspecific rivalry produces a ratio of adult males to adult females of about 2:3 to 1:2 (Hornocker 1969, Seidensticker et al. 1973, Shaw 1977, Logan et al. 1996, Hopkins 1989, Spreadbury 1989, Ross and Jalkotzy 1992, Beier and Barrett 1993, Lindzey et al. 1994, and Logan et al. 1996). Because hunters generally prefer to take large adult males for trophies, this ratio may be even more extreme in hunted populations, especially if there is a restriction on female harvest.

Home ranges tend to conform to natural boundaries, such as rivers, ridge tops and mountain/valley edges (Lindzey et al. 1989). Cougars delineate these boundaries with "scrapes," which are low mounds, a yard or so in diameter, of soil and detritus, often covering feces and used as urination sites (Lindzey et al. 1989, Hansen 1992, and Logan et al. 1996). The combination of visual and olfactory signs apparently serves to warn other lions of trespass and also to inform potential mates of each other's presence (Anderson 1983, Lindzey et al. 1989, Hansen 1992, and Logan et al. 1996). In Utah, cougar home range size is influenced by migratory patterns of prey. Typically, mule deer and elk winter at lower elevations, and are concentrated in much smaller areas. Movements of cougar change as a result during winter months (Lindzey et al. 1989).

Mating, Reproduction, Recruitment, Population Size and Stability

Adults generally represent the highest proportion of a cougar population. Logan et al. (1996) found that in a population with a simulated, limited removal, adults comprised 56% of the population. Adult females comprised 33%, and adult males 23%. Sub-adults accounted for 7%, and kittens 32% of the total. In an unhunted population, adults comprised even a higher percentage (61%), with adult females comprising 35% and adult males 26%. Sub-adults comprised 6% and kittens 33%.

Adult males are in constant search of estrous females as they wander their territories. Scent signals and vocal signals apparently enable the male and female to find each other. When they do find each other, courtship is brief and copulation frequent (Anderson 1983). They might remain companions for a few days, hunting together and sharing meals. Then the male departs, leaving the female to raise the kittens. Cougars first mate between 18 and 36 months of age (Lindzey et al. 1989; Riley 1998), subsequent to the establishment of a home range (Hornocker 1969, Hemker 1982). Females in Utah produce their first litters at an average age of 26 months (Lindzey et al. 1989). The average age of females at first production in New Mexico is 30 months (Logan et al. 1996).

In the course of her life, a female living to 12 years of age could rear about five litters to age of dispersal (Hansen 1992, Logan et al. 1996). Where cougars are heavily hunted, longevity of females may decline, resulting in fewer litters being produced. In addition, older females are most likely more experienced, and therefore, better mothers. The lower the average age drops, the more imperiled the population may become unless there is sufficient recruitment through immigration to compensate for the lower level of productivity.

In an unhunted population of cougars, approximately one of three kittens will live to play a role in reproduction. This is calculated from average survival rates of kittens (0-12 mo.) and subadults (12-24 mo.) (Logan et al. 1996). Therefore, the typical female living to age 12 may produce five reproducers over the course of her life, half of them female. However, it would be a mistake to conclude that an unhunted population of cougars will continue to grow without limit so long as prey is abundant and vulnerable. For one thing, not all reproducing females will live to this advanced age. Further, even unhunted cougar populations do not increase without limit, no matter how abundant and vulnerable prey may be. Due to the inevitable upper limit of the number of available home ranges, determined by level of social tolerance, suitable topography and prey availability, intra-specific conflict, manifesting itself as adult toms kill subadults and unrelated kittens, will tend to increase as the population grows (Lindzey et al. 1989, Logan et al. 1996). An unhunted population will not increase its density above the number of home ranges, which are limited by habitat quality, or tolerated by resident males (Hopkins 1989).

Several researchers hypothesize that cougar populations can sustain up to a 15% annual mortality: 5% from natural causes and 10% from human causes (Jalkotzy et al. 1992, Logan et al. 1996). In a controlled removal experiment in New Mexico, the cougar population was able to rebound from a 28% removal (Logan et al. 1996). This was accomplished mainly by transient animals taking over the home ranges of residents which were removed. However, in a controlled experiment in Utah, the population had not recovered after 2 years from a 30% reduction (Lindzey et al. 1989).

Riley (1998) constructed a stochastic population model to predict changes in the intrinsic rate of growth (λ) of a cougar population from changes in various population parameters, including: adult survival; sub-adult survival; kitten survival; litter size; age at first reproduction; and birth interval. These were modeled against a known population on the San Andres mountains (Logan et al. 1996). Regression analyses indicated that adult survival accounted for the greatest variation in λ. Other variables had less of an impact. Results from empirical studies and Riley's model imply that adult survival must be at least 65% to promote positive population growth. If survival rates in other age classes are lower, or litter sizes are less than average, adult survivorship must be higher for growth to occur in a population.

In southern Utah, adult female survival was determined to be 73% and adult male survival 72% (Lindzey et al. 1994), as compared to 81% for adult females and 90% for adult males in New Mexico (Logan et al. 1996). Causes of death vary between areas, but human-caused mortality is highest in nearly every reported case. Hunting is the primary cause of mortality in hunted populations (Ross and Jalkotzy 1992, Logan et al. 1996), and control measures related to depredation are a primary source of mortality in non-hunted populations (Weaver and Sitton 1978).

It is fortuitous that adult survivorship has the greatest effect on population growth, since it is the factor most easily affected by management (Riley 1998). Cougar management generally involves hunting that targets adult cougar. Hunting season structure, permit levels or quotas have the potential to affect λ of cougar populations, and as a result, population size and density.

Compensation for high adult mortality is not probable within a population (Riley 1998). Litter sizes are not expected to vary appreciably. Compensation from within must then come from either improved kitten survival or reduced age at first reproduction. However, neither variable appears to play a significant role in population growth. Additional recruitment must come from outside the population, most likely in the form of dispersing subadults (Seidensticker et al. 1973).

HABITAT REQUIREMENTS *by* **Rick Danvir** **Mike Bodenchuck**

Cougar occur in a broad range of habitats throughout the west. They exist in hot deserts and sub-alpine forests, urban fringe and remote wilderness. As the name 'mountain lion' implies, however, they most commonly occur in steeper, rugged, rocky terrain dominated by mixed conifer and brushy vegetative cover (Cooperider et al. 1986, Riley 1998). These topographic-vegetative associations are also utilized by mule deer, the principal prey of cougar where they are sympatric (Russell 1978) and are an important component of lion habitat. Large interconnected blocks of suitable habitat for cougar and their prey likely provide optimum conditions for sustaining populations (Shaw 1989).

Cougar habitat can be described and evaluated based on food, water, cover and space requirements. This assessment includes a review of pertinent literature and a discussion of current and future land-use practices on mountain lion habitat.

<u>Components of Cougar Habitat</u>

Food.–Research studies repeatedly identify mule deer as the principal prey of mountain lions (Seidensticker et al. 1973, Ackerman et al. 1984, Logan et al. 1996). Other prey species occurring in Utah include elk, lagomorphs, porcupines, rodents, bighorn sheep feral horses, domestic sheep, cattle, bobcat and coyote (Russell 1978, Ackerman et al. 1984, Turner et al. 1990, Cunningham et al. 1995, Sweitzer et al. 1997). Mule deer availability may influence cougar density, habitat use, and predation on other prey species. Cougar density in a given area is ultimately regulated by a system of land tenure and social intolerance (Seidensticker 1973), and most cougar research supports the hypothesis that lion density is regulated by environmental factors other than prey abundance (Riley 1998). However, prey availability may have some influence on cougar density. Low deer density appeared to both increase cougar home range size and reduce density in southern Utah (Hemker et al. 1984). Lions in mountainous terrain routinely shift to lower elevations in winter, in response to seasonally migrating deer and elk (Ashman et al. 1983; Ackerman et al. 1984; Logan and Irwin 1985).

While many researchers have equated mule deer habitat with lion habitat, Riley (1998) suggested that recent changes in ungulate diversity and abundance may be changing lion distribution and abundance. Increasing white-tailed deer and elk populations in Montana allowed cougar populations to expand their distribution and maintain or increase numbers at the same time mule deer populations were declining.

Most investigators agree that cougar are not a major limiting factor of prey (Hornocker 1970, Russell 1978; Shaw 1977; Logan et al. 1996). However, high cougar:deer ratios appeared to limit deer population growth in the North King's deer herd in California (Neal et al. 1987). Mountain lion predation apparently greatly reduced a population of porcupines in the Great Basin of Nevada (Sweitzer et al. 1997). Cougar are suspected of altering bighorn sheep winter habitat use patterns and reducing populations of bighorn sheep in California (Wehausen 1996, Rubin et al. 1996). Sheep predation increased as bighorns moved to lower winter elevations, thus entering high-density lion habitats. Attempts to avoid lion predation by wintering at higher elevations increased winter energetic demand and reduced sheep condition and lamb production. Conversely, some researchers speculate that predators may have long term beneficial effects on prey and prey habitat, when predator activities induce herding behavior and movements by prey, thereby reducing herbivory and enhancing plant vigor (Savory 1988, Augstine and McNaughton 1998).

Water-The relatively large seasonal ranges and daily movements of mountain lions, coupled with the ability to augment metabolic water needs from prey (Robbins 1993) suggests availability of free water does not greatly influence lion density. However, the availability of free water likely affects the abundance and distribution of cougar prey species, particularly in drier habitats (Robbins 1993, Cooperider et al. 1986). Availability of water sources may influence lion hunting strategy and success. Logan et al. (1996) noted an increase in mule deer predation rates, generally occurring near water sources, during a drought in New Mexico. Drought not only increased mule deer reliance on remaining watering sites (increasing cougar hunting effectiveness) but the drought reduced mule deer fawn production (Logan et al. 1996). Drought, then, may influence prey populations both by reducing the quantity and quality of forage (thus animal condition) and by increasing cougar hunting effectiveness. In situations where forage is abundant and prey populations are limited by free-water, prey abundance and distribution may be enhanced by development of water sources.

Cover (shelter)-Seidensticker (1973) described cougar habitat as a "vegetation-topography/prey numbers-vulnerability complex". He described optimum cougar habitat as a combination of abundant prey and suitable stalking cover for successful hunting. The abundance of prey is partly a result of precipitation in the area (Logan et al. 1996). In Utah, these requirements are available in mountainous country. A landscape devoid of cover is not suitable cougar habitat even if it is home to prey species (Hummel et al. 1991).

Vegetation/Topography-Early studies consistently described cougar habitat as mountainous, broken, rocky slopes and ledges vegetated by an overstory of mixed conifer forest and brush (particularly ponderosa pine, Douglas fir and pinyon-juniper) (Seidensticker 1973, Harcomb 1976, Murphy 1983). Logan and Irwin (1985) quantified cougar habitat use in the Bighorn Mountains of Wyoming. Cougar used mixed conifer (ponderosa pine-juniper) / mountain mahogany overstories and steep (>50%) slopes more than expected. Canyonlands in general contained important lion habitat components. Lions did not select for dense lodgepole, dense Douglas fir, juniper/sagebrush communities and moderate (20-40%) slopes. Sagebrush grasslands and slopes <20% were avoided. Laing (1988) similarly found cougar in southern Utah positively associated with mid-higher elevations, steeper slopes, lava rock, riparian canyons and sandstone ledges; with dense brush and mixed conifer (ponderosa pine and pinyon/juniper) overstories. Riparian zones and rock ledges were the two ecotones most common in high lion-use areas. Areas having low overstory cover, low overstory height and gradual slopes were avoided. Logan (1988) found that habitat quality was negatively correlated with lion home range size. Female home range size decreased as the percent of preferred habitat in the range increased.

Prey numbers/Vulnerability-Mule deer on Utah summer ranges prefer mixed-shrub vegetation types and habitats on steeper slopes (Julander and Jeffrey 1964). Logan and Irwin (1985) speculated that mule deer habitat preferences may provide stalking advantages to mountain lions. Nearly one third of all deer kills examined during their Wyoming study occurred in mountain mahogany communities. They felt trees and shrubs on steeper slopes provided cougars an opportunity for an undetected approach while hunting. Laing (1988) noted the prominence of gambel's oak and bitterbrush in high lion use areas, presumably because of high mule deer densities and suitable hunting cover. He felt lions selected habitats providing the best opportunities for stalking and capturing deer. Optimum cover was defined as areas used by prey, while allowing detection, stalking and close approach of prey by lions. Sparse cover (meadow, slickrock, sagebrush) and extremely dense cover (spruce-fir, aspen/spruce-fir) were avoided. Laing (1988) stated that forested areas containing forb and browse-rich deer forage, interspersed with stalking cover and topographic diversity may be optimal deer/lion habitat.

Van Dyke et al . (1986) noted that resident lions in southern Utah avoided recently logged areas, even though human disturbance had ceased and prey were available. He felt that the removal of large, standing timber (loss of cover) caused lions to avoid these areas. In addition to providing hunting cover; trees, rocks, caves, and steep terrain serve as escape cover for lions from other predators (Laing 1988). Young lions, in particular are vulnerable to attack by both adult lions and other large predators. Selection of timbered, rocky, steep terrain by lions likely evolved as a survival strategy in the Pleistocene, when lions coexisted with a number of much larger carnivores (Elias 1997).

Space-Mountain lions utilize relatively large home ranges, compared to other Utah mammals. The amount of area required by resident lions appears dependent on several factors. Home range size depends on age, sex and reproductive status of the lion; adult males generally utilize larger ranges than females, females with young kittens generally utilize the smallest ranges (Hemker et al. 1984). Average home range size is believed to decrease as prey abundance and vulnerability increase. Mean home range size of resident females may decrease as lion density increases, likely due to social avoidance behavior (Logan et al. 1996). Annual lion home ranges are often larger in mountainous terrain where prey migrate between summer and winter ranges, as compared to lower elevation areas where prey are non-migratory (Hemker et al. 1984, Logan et al. 1996). However, some of the largest home range sizes have been found in desert areas with low prey abundance (Beier et al.1995).

The density of most large carnivores is believed to be a function of metabolic needs and prey availability (Gitttleman and Harvey 1982). Seidensticker et al. (1973) felt that cougar density was a function of vegetative cover, terrain variability, and prey vulnerability related to prey behavior. Riley (1998) developed a model to determine factors important in influencing cougar density in Montana. This model predicted that cover+terrain = habitat, and habitat and ungulate diversity and abundance influenced lion density. Habitat was estimated by determination of a terrain ruggedness index multiplied by the amount of climax vegetation (representing stalking cover). A strong linear relationship was found between this habitat value and the total cougar mortality index for a given hunting district. While there was a strong correlation between total ungulates, represented by total buck harvest for mule and white-tailed deer, and total harvest for elk, and the total mortality index, these factors alone were not as useful in predicting lion densities. However, a two factor model incorporating habitat and white-tailed deer harvest had the highest correlation with the total cougar mortality index. Riley surmised that cover and terrain define habitat quality for mountain lions. Prey abundance is seldom constant and results in increased variability in the system. This is not to say that prey abundance unimportant, rather that because of the variability in prey abundance, it is not useful in predicting lion abundance.

Lion density, then, is at least partly governed by habitat quality. The more suitable the cover, terrain, prey abundance and vulnerability, the less space is required by individual lions. Lion populations in Utah are a product of lion density and the amount of habitat available for lion occupation. But how much habitat is enough to maintain viable populations?

Shaw (1989) provided an estimate of the amount of area necessary to sustain a minimum genetically viable population of cougars. He estimated that in order to maintain genetic diversity, at least 500 breeding age cougar must exist in a spatial arrangement whereby they are capable of interacting to reproduce. Based on published estimates of cougar densities at the time, 10,000 mi^2 of suitable habitat would be required to support such a population. Since suitable habitat is generally unavailable in 10,000 mi^2 blocks, but rather is interspersed with marginal or unsuitable habitat, he estimated at least 30,000 mi^2 of area would be necessary.

There are few (if any) high quality habitat blocks of this size in the west. Rather, good lion habitat generally occurs as mountain ranges and plateaus spatially separated by areas of low quality habitat. Since lions are capable of dispersing relatively long distances (there appears to be a multi-state metapopulation) it appears possible to maintain adequate habitat by joining smaller blocks of suitable habitat together with migration corridors.

In Utah, most large blocks of suitable lion habitat are federally owned mountains and remote canyonlands, as well as a few blocks of state or privately owned lands. In contrast, the migration corridors connecting mountainous habitat blocks are often privately owned foothills, valleys and river corridors. While the federally owned forested lands will largely remain as wildland, the adjoining foothills, valleys and river corridors are largely privately owned and more easily developed. Increasing human presence and development in these areas could impede both lion and prey movement between habitat blocks. Perhaps more importantly, high human density, activity and associated development reduces available big game winter range and increases the frequency of potentially negative human-wildlife interactions.

Logan et al. (1996) suggested incorporating two or more 1000 km^2 (386 mi^2) unhunted refuges to aid management of lions in New Mexico. These areas would supply emigrating subadult lions to adjacent, hunted areas, as well as maintaining a more natural selection process whereby adult males would regulate lion density through a combination of territorialism, cannibalism and infanticide. Several lion refugia currently exist in Utah. Prohibition of hunting in National Parks, military installations and Native American trust lands provide core population areas where lions exist and emigration may serve to increase adjacent hunted populations. By their size, geology, or vegetation, some of these areas (such as Arches and Canyonlands National parks, and Dugway Proving Grounds) provide marginal habitat, while others (such as Camp Williams, Bryce and Zion National parks, the Ute, Goshute and parts of the Navajo reservations) provide high quality habitat. Other areas, open to hunting but with poor or restricted access (for example the High Uinta and Dark Canyon wilderness areas, Kennecott Copper property, or the Kaiparowitz plateau) may serve as defacto refugia for mountain lions.

Effects of Cougar on Prey

The preferred prey species of Utah cougar are deer and elk (Lindzey et al. 1989). Both are typically found in cougar habitat. Where an abundance of both exists, cougars will usually kill more deer (Lindzey et al. 1989), but, because of their larger size, elk might nevertheless account for the greater proportion of total prey biomass consumed (Hornocker 1970, Murphy et al. 1993). Rabbits and hares are also common prey items, though of less significance (Lindzey et al. 1989, Murphy et al. 1993, and Logan et al.1996).

While not a significant portion of the overall diet of cougar, predation of cougar on bighorn sheep has been documented in localized areas in Utah (King 1985; Smith and Flinders 1991).

It is difficult to estimate the average number of deer that an adult cougar kills in a year, but in parts of Utah it appears to average approximately 40 (Lindzey et al. 1989). Females with growing cubs must kill more than others to supply the energy demand of growing offspring. Several researchers have reported that this rate of predation apparently does not reduce the annual average size of healthy deer and elk herds (Hornocker 1970, Lindzey et al. 1989, and Logan et al. 1996). Rather, it probably prevents extreme fluctuations in herd size by reducing the likelihood of both mass starvation and disease epidemics (Logan et al. 1996). In those cases where a deer or elk population has been reduced to a very small size by other causes, predation by mountain lions may slow herd recovery (Lindzey et al. 1989).

Effects of Current and Future Land-Use Patterns on Cougar Habitat

Increasing Human Density - Utah's human population is expected to increase to three million people by 2015, and to five million by 2040 (Utah Division of Wildlife 1998). This expanded population will require additional space for residence, commerce, transportation and recreation; at least partially in cougar/deer habitat. Based on experiences in California, Colorado and other western states, increasing recreational demand on publicly owned lands will negatively impact cougar/prey summer habitat, and increase the probability of human/cougar interactions. However, development of privately owned mountain foothills, valleys and river corridors within commuting distance of urban centers (50 miles) will likely have the greatest impact on mountain lions. These areas are likely to become residential areas. The majority of northern Utah critical deer winter range (80% of DWR Northern Region deer winter range) is privately owned land, currently managed for livestock, farming, hunting and timber production. Shifting from rural to residential land-uses generally reduces the social and biological carrying capacity of these lands for both cougar and prey. Loss of relatively small blocks of privately owned big game winter range to development can effectively reduce cougar and prey densities on vast areas of associated (often publicly owned) summer habitat. Increasing densities of humans, pets and residences means a greater incidence of negative human/wildlife interactions, intolerance of cougar and prey, increased management costs, and death or displacement of offending wildlife. Residential development and transportation corridors further fragment cougar habitat, reducing connectivity and lion movement between habitat blocks.

Habitat Management Strategies

To be managed effectively, cougar and other large mammals must be managed on herd unit, regional and statewide (ecosystem) scales. Cougar/prey habitat complexes must be identified, and at-risk components (winter ranges, connecting corridors) must be functionally maintained. This process will necessitate identifying cougar/prey habitat in Utah using Geographic Information Systems (GIS), available scientific literature, ongoing research, observations by agency field personnel, houndsmen and other individuals with knowledge of lion/prey seasonal habits and movements. GIS based approaches have been successfully used to correlate vegetative-topographic data, prey distribution and abundance, densities of roads and humans, and other land use patterns (such as logging, grazing, mining) to identify areas of suitable habitat for Florida panthers (Belden et al. 1988) and gray wolves (Mladenoff and Sickley 1998).

Critically important cougar/prey habitats must be maintained in "wildland" status using economic incentives such as habitat enhancement programs on private and public lands, cooperative wildlife management units (CWMU), as well as conservation leases, easements or purchases. Although initially costly, maintenance of these habitats will benefit multiple species, maintain agricultural lands and open space. Cougar, bear, elk, deer, moose and a myriad of other terrestrial species utilize the same foothill ranges and migration corridors. Management for one species, in this case, is management for many. A combined effort involving private landowners, state and federal agencies, state and local governments, conservation and open space organizations, and other private interests will be necessary to maintain these critical ecosystem components.

Wildland Management Practices

In general, land use practices which maintain wildland and open space values have less impact on lion habitat than urban/residential/commercial development. Practices such as livestock grazing, timber management, farming, mining and wildland recreational pursuits can have significant or minimal impact, depending on implementation.

Removal of timber and stalking cover, due to logging, mining and fire, can have detrimental effects on cougar habitat, at least in the short term. Van Dyke et al. (1986) noted that resident cougar avoided logged areas in southern Utah, even after human disturbance ceased and prey returned to the disturbed area. He surmised that the habitat had become unsuitable for hunting by lions, due to loss of stalking cover. Transient cougar did not successfully establish in logged areas, areas with high human densities, or areas with high road densities. Hemker et al. (1984) felt that higher road densities resulting from logging and mineral exploration increased the probability that resident females with kittens would encounter cougar hunters. Adult females with kittens, having smaller home ranges, generally avoided roads in low-road density areas. Increased road density and access may alter areas which are currently serving as defacto refugia for cougar populations.

It appears that ponderosa pine, Douglas fir and pinyon-juniper woodlands should be managed for an interspersion of prey foraging areas and lion stalking cover. Extremely sparse timber (poor stalking cover) or dense timber (poor prey forage) should be avoided. Rehabilitation of logged, mined or burned areas may be necessary to obtain suitable plant species and successional response. Total protection of dense, old age timber does not insure optimum lion habitat, since disturbance-successional processes are essential in maintaining prey habitat and abundance.

Grazing by domestic livestock may similarly have negative or positive effects on lion habitat. Over-stocking and continuous grazing regimes, which reduce lion/prey forage and cover values, promote excessive erosion or increase undesirable plant species will affect lion habitat negatively. Time-controlled and rest-rotational livestock grazing practices which increase densities of desirable herbaceous plant species (Savory 1988) or which increase desirable winter browse and stalking cover (Urness 1990) can enhance lion/prey habitat (Augustine and McNaughton 1998). Maintaining lion populations on shrinking habitats means maintaining quality prey habitat; livestock grazing practices can significantly influence habitat quality.

Seasonal livestock presence throughout Utah may serve to increase lion densities by increasing the available prey base (Shaw 1989, Cunningham et al. 1995). Cattle appear to be incorporated as a principal food species when present in a lion's home range year-round (Shaw 1989). Livestock presence may (by providing additional or alternative prey) influence the densities of lions and native prey species.

Intolerance of lions due to livestock depredation can lead to low lion densities in otherwise suitable habitat. Cunningham et al. (1995) suggested depredation may be minimized by not grazing calves and sheep in steeper, mixed conifer habitats frequented by hunting lions. The presence of herders, guard animals and short duration grazing practices may also minimize livestock losses in lion habitat. Identification and removal of specific depredating lions has significantly reduced losses of both livestock and bighorn sheep (Cunningham et al. 1995).

Farming practices which replace lion/prey habitat with crops can reduce carrying capacity through habitat loss and depredation hunting. Farms are often the site of cougar/livestock and cougar/human problems. Conversely, agricultural fields can provide high quality prey-foraging areas, relatively safe from hunting by cougar. Incentives to landowners to allow deer access to crops in spring or during times of drought may serve to maintain or increase prey abundance and enhance cougar habitat.

ASSESSING COUGAR ABUNDANCE *by* Dr. Michael Wolfe

As defined by Lancia et al. (1994:216) a population estimate is "an approximation of the true population size based on some method of sampling animals, such as by capturing or counting them." Because of the difficulties involved in observing or capturing a secretive species such as cougars, attempts to document abundance of these animals often rely on indices that are related to population size. Indices may be used in comparisons between individual populations or of the same population over time. In many cases the exact relationship between an index and the actual population size is not known. A trend is a statistic reflecting the average direction and magnitude of change of a population over time. Trends can be derived from either formal population estimates or indices.

An important notion in any attempt to estimate an animal population is that of precision. This concept differs markedly from that of accuracy. Obviously, we want our population estimates to be "on the mark" (i.e. accurate), but we also want them to be consistent. In other words, if we make several estimates of the same population, we should have confidence that they will fall within an acceptable range of error. This is akin to a tight group of shots in archery or shooting a firearm. Accurate estimates are not always precise and *vice a versa*. Note that an accurate estimate that lacks precision is analogous to a lucky shot. On the other hand, if estimates are precise but not accurate, then we say that they are biased, either high or low. The nature of the bias depends upon the estimation procedure involved, but generally the degree of precision is positively related to sample size.

A related concept is the "power" of a statistical test that one might employ to discern a change (say a decrease) in a population that is estimated at two points in time. The probability of correctly detecting the nature of a change that has actually occurred is called the power of a test. This "power" is a function of the level of significance (i.e. risk of not detecting that a change occurred due to chance), sample size, the variance inherent in the respective estimates of the population, and the type of statistical test used to make the comparison. See Ratti and Garton (1994) for further discussion of this concept.

<u>Population Census</u>

Techniques that have been used to estimate cougar numbers can be summarized as follows: (1) track counts; (2) scent-station visitation rates; (3) indices of catch-per-unit effort; and (4) capture-recapture estimates.

Track Surveys.–By far the most widely used approach to evaluate cougar abundance are track counts. This approach represents an example of an index that is not associated with a formal population estimator. Typically, track counts have been used to document relative abundance of the animals and monitor changes in population size. These counts may be ground or aerial based and are conducted in various seasons of the year. Ground-based track counts in snow-free environments have received most attention in Arizona, California, and Nevada. Van Dyke et al. (1986) reported a positive linear relation between mountain lion sign and the density of animals in an area. Smallwood and Fitzhugh (1995) recommended censusing in areas of medium density rather than those of high or low densities, because these would be most suited for monitoring trends over time or making comparisons between areas. Beier and Cunningham (1996) evaluated the statistical power of track surveys to detect temporal changes between two annual surveys. They found that track transects had low power to detect annual changes of relatively small magnitude, thus necessitating a large number of transects. For example, detecting an increase or decrease of 30% at a probability level of 5% would require 140-190 transects of 8-km length. If it is necessary to detect only large decreases (i.e 50%), they are more powerful, with only about 50 transects required for 80% at a probability level of 0.05 and even fewer at less demanding probability levels.

Van Sickle and Lindzey (1991) developed a procedure that used probability sampling of cougar tracks in snow as a method of obtaining a formal estimate of the number of animals present in an area. The probability sampling technique (Becker 1991) entails traversing a series of parallel transects after a snowfall and following the tracks of individual cougars that intercept the transect from where the animal began its movement after the snowfall to its current location. The approach assumes that cougar tracks are identifiable and not missed if they cross the transect and can be followed for the entire length of the animal's movement. Van Sickle and Lindzey (1991) conducted computer-simulated surveys based on empirical movement data from a known population of cougars to evaluate the effects of survey design and the influence of density on the precision of the estimator. Precision of the estimator increased: (1) in proportion to the number of transects in each systematic sample; (2) when transects were oriented perpendicular to major drainages; and (3) when they were flown 2 days rather than 1 day after a snowfall. The increased affordability and effectiveness of portable global positioning instruments has facilitated the application of this approach.

Wolfe et al. (unpublished data) attempted to apply this technique on the Monroe Mountain unit in 1997 and 1998. The single greatest obstacle to its efficacy was the limited occurrence of favorable snow conditions, namely a snowfall of sufficient depth (10-20 cm) to obliterate old tracks and which persists for at least 48 hours on south-facing slopes. In addition, optimum observational conditions require bright sunshine to highlight tracks. The convergence of such conditions occurred on only a single occasion in each of the two winters. Since a single survey does not allow for a direct calculation of variance, we derived standard deviations for the population estimates using bootstrap and jackknife methods. The bootstrap technique was performed using 1000 iterations in the program SYSTAT (SYSTAT Inc., Evanston, IL). The Jackknife estimate was derived by removing one of the transects in each survey, deriving a population estimate from the remaining samples, and then using the mean of these population estimates to derive a variance. Using the Jackknife standard deviation the population estimate decreased from 41.2 ± 23.0 in 1997 to 31.7 ± 11.4 in 1998. The point estimates for the respective years agreed reasonably well with estimates of minimum population size derived from intensive capture efforts. However, the estimates of precision were conservative, given the limitations of aerial sampling discussed above. In particular, there is a high risk of inflation (or deflation) of population size from measurement errors of as little as 0.1 km track length, x_i. The poor precision of these estimates precludes meaningful statistical comparison of population estimates between years.

Estimates Based on Captures.– Mark-recapture methods have a long history in wildlife management. The conceptual framework dates back to at least the 18th century (Manly and McDonald 1996), and during the past 50 years has spawned an entire family of variants. In its simplest form, the approach entails marking and releasing some fraction of the members of a population. In a subsequent sampling event, the number of marked and unmarked individuals captured is recorded. An estimate of the number of animals in the population at the time of the first sample is developed from the proportion of marked animals (m) recaptured in the second sample to the total number of individuals captured on that occasion (n), which is assumed to be equal to the ratio of the number of animals initially (M) to the total population at that time (N).

While the concept is appealingly simple, it is often exceedingly difficult in practice to meet its underlying assumptions. The most important of these is that of not diluting or inflating the ratio of marked animals in the populations between the first and second sampling occasions. Practically, this requires "geographic closure" of the population, namely no immigration of animals into the area being sampled and no emigration (or at a minimum that the ratio of marked and unmarked migrating animals matches that of the population as a whole). In addition, the technique is rather sensitive to sample size, both in terms of the fraction of the population marked initially and the proportion of marked animals recaptured on the second occasion. In very general terms, it is necessary to mark approximately 30% of the individuals in the population to obtain acceptable levels of precision.

Most attempts to use mark-recapture methods for cougars have involved animals captured and outfitted with radio- and/or visual collars. Other approaches which do not involve physically capturing and handling the animals have been proposed. These include remote marking with paint balls or biological dyes. Such an approach have the potential advantage of involving sportsmen to obtain statistically appropriate sample sizes for a given unit. A significant limitation is the necessity of using a marking agent which will maintain its identity for a period of several months but can be removed when the animal is killed so as not to degrade the trophy quality of the pelt.

Currently, we are investigating the feasibility of using genetic marking (DNA "fingerprints") of tissue samples obtained remotely in conjunction with capture-recapture methods as a procedure to estimate cougar populations.

Catch-per-unit-effort (C/E) estimators are based on the premise that as progressively more individuals are removed from a population, fewer are available to be caught. Accordingly, it requires a greater expenditure of effort to "catch" (observe, capture or kill) an additional animal. In the case of cougars, fewer animals would be treed or killed per pursuit or hunter day. C/E can be applied as either a formal population estimator or, more commonly, as an index of population size.

An important limitation to the application of this approach is the assumption that the probability of catching an animal during a specified interval of time remains constant over time and among participants. In practice, this assumption is frequently not met due to variations in weather conditions and differential hunter abilities. Accordingly, there has been a reticence on the part of wildlife managers to use this index, even though the informational inputs are relatively easily and inexpensively obtained. This notwithstanding, the approach should be explored more thoroughly, perhaps by using a selected set of houndsmen and establishing “correction factors” for the quality of weather/tracking conditions on any given occasion.

In conclusion, it should be noted that no single technique is likely to be universally applicable to all locations or situations, because of site-specific differences in terrain and substrate conditions, snowfall patterns and persistence and extent of tree cover. Moreover, although each index of population trend is subject to its own limitations, the fact that multiple indices may indicate the same general direction serves to increase one’s confidence in the conclusion that the actual trend of the population is indicated.

Projection Methods

Biologists have long attempted to verify their often imperfect empirical knowledge of a population’s performance with hypothetical simulations of population dynamics. These approaches, often referred to as modeling or population projection techniques, range from very simplistic to sophisticated. The advent of computer technology has greatly facilitated the often tedious calculations involved in population projections. Currently, there are several commercial software packages available that can be used for this purpose.

Most “models” are based on some variant of an age- or stage-structured matrix (Leslie 1945). Unfortunately, this does not guarantee that the models accurately portray what is actually happening in a population. Regardless of its complexity, how well a model mimics reality depends upon the accuracy of the input variables for reproduction, mortality and migration used in the model (Jenkins 1988). In blunt terms “... garbage in = garbage out”. Frequently, seemingly very small and often indiscernible differences in certain critical population parameters can produce substantial differences in the dynamics of the population being modeled.

Most efforts at modeling populations are “deterministic”. In simple terms, this means that the input parameters remain constant rather than varying randomly through their potential range of variability, as is the case in so-called “stochastic” models. The latter are of course more realistic. Given the apparent density dependence in cougar population dynamics (see below) realistic models will also incorporate some provision to simulate this feature.

One drawback of using models to project the dynamics of cougar populations is that certain demographic variables (i.e. kitten survival) may be influenced by the abundance and availability of prey (Logan et al. 1996). Thus it is difficult to assign reliable estimates of these parameters without knowing something about the relative abundance and vitality of the deer herd as well as the potential availability of alternate prey species.

Lindzey (unpublished) recognized this problem and developed a procedure for estimating an allowable harvest for sustained yield of cougars. The approach involves four steps. The "total cougar habitat" on a given unit is estimated as more or less equivalent to the areal extent of the amount of available deer habitat in the unit. This estimate is applied qualitatively to a range of cougar densities (low, medium or high) determined from the literature to obtain an estimated unit population. The latter estimate is multiplied by 70% to remove legally-protected kittens and arrive at a harvestable population. This is in turn multiplied by 20% to estimate an "allowable kill" figure for the unit.

The approach described above incorporates several critical assumptions, perhaps the most important being that of equating cougar habitat to available deer range. Presumably, the quality of cougar habitat is reflected in relative densities applied in the second step of the process. Greater quantification at this level that incorporated GIS technology and at least crude estimates of deer densities and the availability of alternate prey species (e.g. elk) would conceivably improve the quality of the estimated harvestable population.

Effects of Exploitation

As documented by the results of studies in disparate locations (Hornocker 1970, Murphy 1983, Ross and Jalkotzy 1992), sport hunting constitutes the largest source of mortality in hunted cougar populations. However, in unhunted or very lightly hunted populations, social interactions (Hornocker 1970, Seidensticker et al. 1973, Logan et al. 1996) or prey densities (Hemker et al. 1984) may be more important in limiting populations.

Density dependent mechanisms appear to influence cougar populations substantially. In many instances, immigration of transient cougars compensates for decrements from the adult component of the population, whereas young animals dispersed from the area they were raise in, when they became independent. In New Mexico Logan et al. (1996) reported that the annual rate of increase of the San Andreas Mountain (SAM) population varied between 17% and 28% when the population was low, but declined to $\leq$5%, when the density of prey was low. Although, on occasion, vacant home ranges may be filled by adults, which may serve to add stability in a population (Cunningham et al. 1995).

The effect of hunting on cougar populations will depend upon both the level of kill and the sex and age of the cougars removed. Generally, populations will be most impacted by loss of adult resident females. An important question is the degree to which losses to hunting will be compensated for by a reduction in other mortalities normally incurred in cougar populations. Lindzey et al. (1992) concluded that such compensation was only partial at best, and attributed this to generally density-independent nature of causes of death (e.g.

prey captures, vehicular accidents). In British Columbia, Spreadbury et al. (1986) observed that 57% (4 of 7) of the documented mortalities were human-related (vehicular) despite the area being closed to hunting.

A few studies have investigated the demographic effects of experimental removals of cougars. In southern Utah, Lindzey et al. (1992) reported that a population subjected to an experimental removal equivalent to the average annual mortality for adult residents (28%) when unharvested failed to recover to its preremoval level for at least 2 years. Similarly, in New Mexico Logan et al. (1996) reported that it required 31 months for the adult segment of the population to recover from a loss of 58%.

There appears to exist an inverse relationship between hunting pressure and its impact on the population. Due to hunter selectivity for larger males, light to moderate hunting pressure (such as typically occurs under a limited entry system) results primarily in the removal of males from the population. Barnhurst (1986) calculated relative vulnerability of various sex and age/social classes and found that transient males had the highest vulnerability indices of all classes.

The postulated effects of removing resident males from the population are the subject of some controversy. Cannibalism of kittens by adult males has been reported widely (Lindzey 1987), and has been proposed as a strategy to increase their reproductive fitness, because loss of a litter may induce estrous in females, and provide additional breeding opportunities on the part of resident males. It has been suggested that removal of resident territorial males could have a stimulatory effect on a cougar population by enhancing survival of kittens and subadult males (MDFWP 1995). However, Ross and Jalkotzy (1992) argued that where a resident male remains established for several years, most progeny of resident females would be his own offspring, thereby making cannibalism a poor strategy. They speculated that harvest strategies that remove a large portion of the male segment could actually result in increased kitten mortality.

Heavier hunting pressure (such as may occur under a quota system) generally results in a greater removal of females and possibly attenuation of the age structure. This dual effect has multiple demographic consequences. It reduces the potential of the residual population to replace hunting losses, and may result in orphaned kittens.

In Utah, an approximate 3-fold increase in the number of permits issued between the early 1990's and the 1996-97 season resulted in an increase in the percent females taken from 32% to 42%. The mean age of females among hunter-killed animals was 3.6 years. The survival rate calculated from the age distribution of the kill by means of the Chapman-Robson (1960) procedure was 0.58, S.E. = 0.06).

Most cougar hunting seasons are scheduled during winter months, when snow conditions favor tracking (Lindzey 1987). During the early winter period, many females are accompanied by kittens <6 months of age. Although regulations may protect females with dependent kittens, hunters may not know whether a given female is accompanied by dependent young. In Utah, Barnhurst and Lindzey (1989) reported that tracks of kittens <7 months old were found with those of their mothers only 19% of the time. Hemker et al. (1986) noted that 2 of 3 kittens orphaned at 6 months of age perished before dispersal.

Ross and Jalkotzy (1992) recommended a quota system that limited female harvest as a means of reducing pressure on the female segment.

PREDATOR/PREY RELATIONSHIPS *by* Dr. Michael Wolfe

Predation Impacts

Cougars, like other large felids, are morphologically adapted to kill prey as large or larger than themselves (Kruuk 1986). They kill and consume a wide variety of prey from juvenile moose (*Alces alces*) to lagomorphs (hares and rabbits) and small mammals. Over much of North America, however, deer (*Odocoileus* spp.) constitute their principal prey. Depending on location, deer can account for roughly 30-80% of an individual cougars diet. Deer represent an optimum prey size with respect to energetic costs of capture and risk of injury as opposed to the amount of energy obtained. There exists some disparity of opinion within the literature as to the significance of non-ungulate species to cougars. Ackerman et al. (1986) suggested that successful reproduction in North American pumas is dependent upon significant numbers of ungulates and that maintenance of populations on smaller prey, e.g. lagomorphs, is unlikely. However, pumas in South America, which have larger body sizes that their North American counterparts, take smaller prey and have broader diets (Iriarte et al. 1990; Branch et al. 1996).

Most estimates of the number of deer killed by cougars derive from consumption rates based on observations of captive animals and/or energetic models. Estimates published by Ackerman et al. (1986) spanned a range of 2.4-4.3 kg of deer meet per adult animal per day. Extrapolation of such estimates typically lead to estimated kill rates of one adult deer every 4 to 10 days. These estimates lead to unreasonably high postulated impacts on deer populations because they fail to consider scavenging by cougars and the use of alternative prey.

To what degree predation by cougars actually limits the growth of their principal prey populations is the subject of considerable controversy. Most who postulate a significant negative impact, such as Neal et al. (1987), base their arguments largely on circumstantial evidence, namely the large fraction of deer that comprises the cougar diet, high cougar densities, and declining deer populations. Evaluations by other authors are less simplistic. For example, on the North Kaibab in Arizona, Shaw (1977) concluded that cougar were a major cause of deer mortality contributing to low deer population levels. However, cougar predation alone would not prevent the deer herd from increasing if other losses (e.g. hunting) were significantly reduced. Likewise, Logan et al. (1996) working in the San Andres Mountains in New Mexico noted that cougar predation was the major cause of death in mule deer, but that habitat quality was the ultimate limiting factor. When habitat quality was good and the deer population was below carrying capacity, cougar did not prevent the deer population from increasing. However, during periods of drought, when the deer population exceeded the carrying capacity, cougar predation exacerbated the deer population decline. Similar conclusions were drawn by Hornocker (1970). Hemker 1982) calculated that cougar predation accounted for only 13% of all deaths sustained by mule deer of all age classes on the Boulder-Escalante area in southern Utah. The proportion of adult animals killed by cougars was, however, considerably higher, accounting for 41% and 35% of adult females and males, respectively. Cumulatively, the results of these and other studies indicate that deer populations in habitats of low quality with generally poorer fawn production, such as those in desert areas, are more subject to limitation by cougar predation. Other factors influencing the effects of predation include the presence of additional predators and alternative prey species.

The “Predator-Pit” Concept

For some years, control of wolves (*Canis lupus*) and bears (*Ursus* spp.) in Alaska and the Yukon Territory of Canada has been justified on the basis of the “predator pit” paradigm. This theory is based on the notion that two alternative equilibria can exist in predator-prey systems. Note that the term equilibrium does not connote absolute constancy in numbers of predators and prey, but rather the tendency of the system to return to the vicinity of the equilibrium if one or the other component undergoes substantial change (NRC 1997). According to the multiple equilibrium hypothesis, prey populations and their predators can coexist at low population levels, in which case growth in prey numbers is limited primarily by predation. Alternatively, the two players can exist at high densities, and in this state the prey population is limited by resources (i.e. carrying capacity). The concept of a predator pit has been documented in some ecosystems with endangered species. It is intuitively appealing to some wildlife managers, because it provides justification for predator control (at least over the short term) in order to release the prey population and allow it to grow toward the higher equilibrium.

Van Ballenberghe (1987) argued that two-predator / single-prey systems show a greater propensity to be stable at low densities than are one-predator / one-prey systems. Empirical evidence indicates that wolves and brown bears (*U. arctos*) in combination can depress moose populations. The more important question is whether wolf predation can maintain this equilibrium state for longer periods of time (Sinclair 1989). On this point the available evidence is equivocal and lends itself to varying interpretations.

An analogous scenario may exist with respect to cougar-deer interactions. Mule deer are subject to predation by cougars as well as coyotes and black bears. The principal impact of the latter two predators occurs within the first 3-6 months of life, whereas cougars prey upon deer throughout their life, but primarily as older fawns and adult animals (Knowlton 1975; Smith 1982). Because these predation events occur in essentially a sequential rather than concurrent manner, they are probably additive and not compensatory in their effect on the deer population. Further research is needed to evaluate the effects of multiple prey species, such as elk and/or lagomorphs, on the cougar/deer predation system.

MANAGEMENT HISTORY *by* Bill Bates

Little is known about the use of cougar by native Americans in Utah. However, cougar were apparently present before European settlement. Illustrations of cougar are found at two rock art sites in Utah. Cougar tracks are depicted on another (Rawley 1985). The frequency of wildlife species at rock art sites is not believed to signify relative abundance. It simply indicates that native peoples were familiar with cougar, and therefore, indicates they were present in the area.

While early written histories of trappers and explorers fail to mention the cougar, they did not go unnoticed by early settlers. In December, 1847, several months after the Mormon pioneers arrived in the Salt Lake Valley, there was serious depredation of livestock by wolves, foxes, and catamounts (cougar), and great annoyance occasioned by the howling of some of these animals. Two hunting parties were formed for the extermination of wild beasts. Eighty-four men in the two parties killed 2 bears, 2 wolverines, 2 wild-cats, 783 wolves, 400 foxes, 31 mink, 9 eagles, 530 magpies, hawks and owls, and 1626 ravens (Rawley 1985). Wild-cats probably referred to bobcats, and the wolves most likely were coyotes.

In 1855, Jules Remy included the American panther (*Felis concolor*) in his list of the fauna of Utah (Remy 1861). While Captain Howard Stansbury did not include the cougar in his list of the mammals of Utah in 1850, it was noted that neither the panther nor the bear were as feared on the trail as the wolverine, which would ferret out caches of provisions and skins and was a great nuisance (Rawley 1985).

In March, 1888, the Utah Territorial Legislature passed a bill that initiated bounty payments on obnoxious animals, including; lynxes, grey wolves, wild-cats, coyotes, mountain lions, bears, jack-rabbits, ground squirrels, muskrats, minks, weasels, gophers and English sparrows. Following statehood in 1896, the first State Legislature repealed the first act and enacted a similar law to provide for the payment of rewards for the destruction of certain wild animals and birds (Rawley 1985). A payment of not less than five dollars nor more than ten dollars was included for both mountain lions and bears.

Although not continuous, records were kept on the number of cougar and other predators bountied in Utah from 1913 to 1959 (Durrant 1952; UDWR files 1998). A federal control program was initiated in 1917 to take mountain lions and other predators in depredation situations to protect livestock. This was administered by the U.S. Fish and Wildlife Service until 1966, when it was reassigned to the Department of Agriculture. Bounty payments were not continuous over the period, with no bounties being offered from 1932 to 1943. Federal agents were active in control efforts in every year after 1917, except 1946.

As a result of a petition filed by houndsmen, in 1967, the Utah State Legislature changed the status of cougar and black bear from predator to protected wildlife. Management responsibility was given to the Utah Department of Fish and Game. The Utah Fish and Game Commission, at its meeting on January 25, 1967, declared the cougar to be a game animal and established hunting regulations (Bowden and John 1974). Regulations became effective February 15, 1967, and allowed the taking of any number of cougar at any time. Residents were not required to have a permit, but non-residents were, at a cost of $150. In addition, non-residents acting as guides were required to purchase a guide permit for $300 (Table 1). The bag limit on cougar was reduced to 2 in 1970, and then to 1 in 1971. Hunters were first required to check in their cougar in 1972. Females with kittens, and kittens with spots were first protected from harvest in 1972. Guides were no longer required for non-residents in 1981. Beginning in 1975, some areas of the state were closed to cougar hunting. This continued through 1979. Both the Henry Mountains, from 1975-79, and Boulder Mountains, from 1979-84, were closed to conduct research on cougar.

Table 1. Summary of cougar harvest regulations in Utah, 1967-99.

Year	Season length	Bag limit	Resident permit ($)	Non-resident permit ($)	Comments
1967-8	year long	unlimited	none	$150	Non-res. guide $300
1968-9	year long	unlimited	required $0	$50	Res. guide $20; N-res guide $150
1969-70	year long	unlimited	$1	$50	same
1970-1	year long	2	$1	$50	only resident guides
1971-2	Nov 1-Apr 15 north; year long south	1	$15 + big or small game lic.	$100 + other lic. + guide	
1972-3	Nov 1-Apr 15	1	$15 + other lic.	$100+ other lic. + guide	females w/kittens protected; check-in w/CO required
1973-4	Nov 1-Apr 15	1	same	same	livestock owners allowed 1 free depredation permit
1974-5	Nov 1-Apr 15	1	same	same	

1975-6	Nov 1-Apr 15	1	same	same	Northern Region and Henry Mtns. closed; livestock dep. perm. $15
1976-7	Nov 1-Apr 15 Southern Reg-yearlong	1	same	same	NR + Henry Mtns closed
1977-8	Nov 1-Apr 15 SR-year long	1; 2 in SR	same	same	second cougar permits same cost ($15, $100)
1978-9	Nov 1-Apr 15 SR-year long	1	same	same	check in within 48 hrs.
1979-80	Nov 1-Apr15 SR-year long	1	same	same	Henry Mtns opened; Boulder Mtns closed; NR-limited entry permits
1980-1	year long	1; SR-2	same	same	25 second cougar permits available in SR
1981-2	Nov 2-Apr 15, with exceptions	1; 2 in SR	same	same	Central Utah-closed; Dec 1-Feb28 in northeast; year long in southwest
1982-3	same	1; 2-SR	same	same	Same, ex. limited entry in central and northern (25)
1983-4	same	same	same	$250	19 LE permits in central and northern
1984-5	Jan 1-Aug 1 SR year long	same	$25	$250	Portions of central Utah closed; LE in north and central and Boulders
1985-6	Jan 1-Aug 1; south-year long	same	$25	$250	LE in north and central
1986-7	Jan 1-Jul 31 south-yr.lng.	1	$25	$250	57 LE permits in north and central
1987-8	Jan 1-Jul 31 south-yr.lg.	1	$25	$250	79 LE permits in north and central
1988-9	Jan 2-July 31 south-yr.lg.	1	$25	$250	91 LE permits in north and central
1989-90	Jan 1-Jul 31; unit 30 yr.lg.	1	$53	$253	Statewide limited entry permit system, 527 per.
1990-1	12/18-6/8; unit 30 yr.lg.	1	$53	$253	Statewide LE-527 permits
1991-2	12/18-6/8; unit 30 yr.lg.	1	$53	$253	Statewide LE-527 permits

1992-3	12/18-6/8; unit 30 yr.lg.	1	$53	$253	Statewide LE-591 permits
1993-4	12/18-6/8; unit 30 yr.lg.	1	$53	$253	Statewide LE-659 permits
1994-5	12/17-6/4; unit 30 yr.lg.	1	$53	$253	Statewide LE-791 permits
1995-6	12/16-6/3; unit 30 yr.lg.	1	$53	$253	Statewide LE-872 permits
1996-7	12/14-6/7; unit 35 yr.lg.; unit 34 11/14-6/7	1	$53	$253	31 limited entry sub-units with 595 permits; 29 harvest objective sub-units with quota of 275
1997-8	12/14-6/7; unit 35 yr.lg.; unit 34 11/14-6/7	1	$53	$253	25 LE sub-units with 509 permits; 18 HO sub-units with quota of 270
1998-9	12/16-6/9; units 29&26 year long	1	$53	$253	30 LE sub-units with 446 permits; 16 HO sub-units with quota of 230

Beginning in 1979, closed areas in northern Utah were opened to limited entry hunting. Other cougar management units near human population centers along the Wasatch Front, particularly those with higher densities of cougar and better access, such as Diamond Fork and Spanish Fork canyons in central Utah, received significantly higher hunter pressure in the late 1970's and early 1980's compared to units in the southern part of the state. As a result, these areas were closed in 1981-2. These units were opened to limited entry hunting in 1982-3. This allowed a limited number of hunters who drew a permit to take a cougar, while leaving these same units open to hunters who wished to pursue cougar only. This management system, limited entry hunting in northern and central Utah coupled with unlimited permits throughout the rest of the state, continued until 1989-90.

Wildlife managers in Utah became concerned with cougar hunting in 1988. The number of hunters afield increased 36 percent, from 486 in 1987, to 662 in 1988 (Bates 1989). At about the same time, the Boulder Mountain Cougar Study was coming to a close, and researchers developed a model to predict allowable harvest by management unit. In an effort to spread out hunter pressure and keep cougar harvest close to levels set by the model and near the long-term average harvest in each unit, a limited entry permit system was established statewide. Permit levels were set assuming that 50% of the tags would be filled. The limited entry permit system was not designed to reduce harvest, and, with the exception of the 1989-90 season, the number of cougar harvested continued to increase. The sport harvest of cougar under the limited entry system ranged from 217 in 1989-90, to 452 in 1995-96 (Evans and Blackwell 1997).

Much of the state of Utah suffered from an extended drought from 1990 to 1996. As a result of this and other factors, mule deer populations throughout the state declined sharply. A statewide cap of 97,000 buck deer tags was set in 1994, down from the long term average of over 180,000 deer hunters per year. Limits were set on the number of permits sold in each of the Division's five regions. Deer herds in some units responded quickly, particularly in the southwestern part of the state. However, others did not. Several deer herd units in southeastern Utah were closed to hunting. While drought and habitat loss were acknowledged, many hunters felt that predators were contributing to low deer numbers and asked the Utah Wildlife Board to increase cougar permits.

In 1996, the Utah Wildlife Board passed a Predator Management Policy. Under the assumption that predators can slow recovery of prey populations when they are depressed (Smith 1982; Neal et al. 1987), predator management plans were prepared for 15 units or sub-units where prey populations were at least 50% below target levels and not increasing. Wildlife Services was asked to focus their efforts in most of these units to remove coyote pairs in deer fawning areas before fawns were born. In other units, predator management plans were prepared to benefit bighorn sheep or pronghorn and Wildlife Services focussed their efforts to reduce coyote predation on the young of these species.

In an effort to reduce cougar population levels in these units to aid in prey recovery, the Utah Wildlife Board established a harvest objective management system in 29 of 60 cougar management sub-units. A quota was established for each of these units, and any number of hunters could hunt the unit until the quota was filled. Some units were open as little as two weeks, while the majority were open for the entire 5 ½ month season. The remaining 31 units were managed as limited entry units. Cougar permits were increased on limited entry units with an approved predator management plan. As a result, the 1996-97 season had the highest number of hunters afield (1376) and the highest sport harvest (576) recorded since the cougar became a protected species.

Aided by improving weather conditions, deer populations in some units with predator management plans had improved by 1998. As a result, cougar permit levels or quotas were reduced in these units. Currently the state is still divided into 46 units/sub-units, with 30 being managed as limited entry, and 16 as harvest objective. Parameters used to evaluate population status and trend included the percent of females and sub-adults in the harvest, hunter success, and the average age of cougar in the harvest. Hunters were required to give the UDWR a tooth from each cougar harvested. The tooth was sectioned and age estimated from counting cementum annuli. Other methods of population estimation are being investigated, such as scent post and track surveys, and using DNA markers obtained from houndsmen for mark-recapture population estimates.

Cougar Management in Surrounding States

The cougar is a large, mobile predator, capable of traveling long distances. Marked cougar from Utah have moved to surrounding states when dispersing from natal areas. Cougar in Utah are undoubtably part of a larger population extending into adjoining intermountain states. The number of cougar in Utah is most likely influenced by hunting regulations set by other states. The following is a state-by-state summary of harvest regulations in 1998.

Colorado-Cougar are managed by the Colorado Division of Wildlife, and became a protected species in 1967. In 1997-98, the cougar season ran from November 9 to March 31. Harvest is controlled through a quota system, with a quota set for each unit. Hunters are required to call an 1-800 number prior to hunting to make sure the unit is still open. Hounds are allowed, but pack size is limited to eight. Total sport harvest in 1997-98 was 441 mountain lions (Siedel 1998).

New Mexico-A long range plan for the management of cougar in New Mexico was completed in 1998. The goal of the plan is to satisfy people's recreational and ecological interests, and successfully resolve cougar-related issues (NMDGF 1997). The objective is to reach 75% public satisfaction by 2004. The cougar became a protected species in 1971. New Mexico did not restrict the number of licenses sold prior to 1991. The season ran from December 1 to March 31. Hounds are allowed. From 1985 to 1997, the average harvest was 115 per year. The highest harvest recorded was 177, in 1996-97. One-hundred sixty-eight cougar were taken in 1997-98. Beginning in 1999-2000, the New Mexico Game and Fish Commission has approved implementation of a quota system. The state-wide quota has been set at 176 cougar. The season length has been extended, and will run from October 1 through March 31 (Hayes 1998).

Arizona-The goal of the Arizona Game and Fish Department is to manage the mountain lion as an important part of Arizona's fauna, and to provide hunting and other related recreational opportunities (AGFD 1995). Their goals include maintaining an annual harvest of 250 to 300 mountain lions and to maintain existing occupied habitat. Cougar hunting is open to a year-long season. However, on six of 79 management units, a quota of one has been set. The season closes the Friday following filling the quota. Sport harvest of cougar in 1997-98 was 267. Forty-seven cougar were also taken in depredation situations (Phelps 1998).

Nevada-The mountain lion became a protected species in Nevada in 1965. The Division of Wildlife manages cougar for its intrinsic values and other benefits. Cougar are allowed to fulfill its ecological role as a major predator, but in specific instances where predation may jeopardize another wildlife population, specific mountain lion populations may be reduced. Efforts are also made to reduce economic impacts of predation by cougar on livestock (NDOW 1995). Nevada uses a harvest objective system to control harvest. The state is divided into 32 management units. The season opens October 1 and closes April 30, or when the harvest objective is reached. The statewide harvest objective was 292 in 1998, and 214 cougar were taken by sport hunters. An additional 25 were taken by

Wildlife Services in depredation situations (Stiver 1998).

Idaho-The cougar became a protected species in Idaho in 1972. They are managed to provide continued recreational opportunity for consumptive and nonconsumptive resource users. Mandatory check-in of harvested animals and telephone surveys are used to monitor harvest. Several of the objectives of the mountain lion management plan in Idaho are to reduce the percent of females in the harvest to 25-35%, and to implement female quotas in management units. In 1998, 31 of 88 management units had an established female quota. Season length varied by management unit, but generally ran from September 15 to March 31. Several units closed February 16 and had a dog training season through March 31. Sport harvest in Idaho has steadily increased, and was 632 in 1996 (Beecham and Harris 1997).

Wyoming-Wyoming Game and Fish Department manage cougar harvest through a mortality quota system. The mortality quota includes sport harvest, depredation harvest, accidental trapping, road-kills, or other types of human-caused mortality. A quota is set for each of the 27 management units. A female sub-quota has been established on 5 units. The season begins September 1 and runs through March 31, or until the quota has been filled. Hounds are allowed. In 1996-97, the mortality quota was reached in 18 of the 27 units. The total recorded mortality for the 1996-97 season was 151 (WGFD 1996). The statewide quota for 1998-99 was set at 459 cougar.

USE AND DEMAND

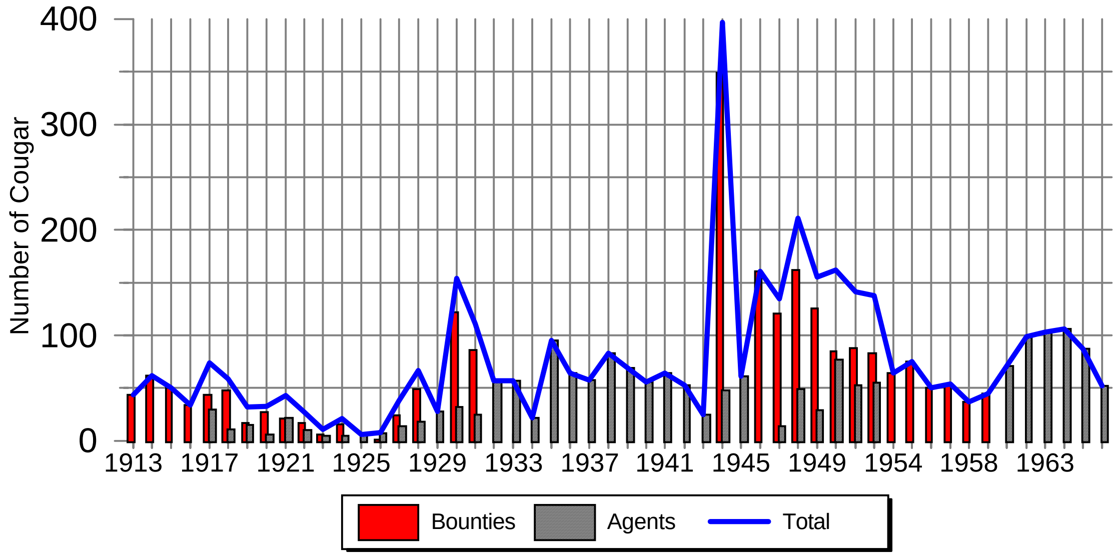
by **Mike Bodenchuck, Don Peay, Byron Bateman, Bill Bates, Kirk Robinson**

The public demands for use of cougar are broad and varied. There are those who enjoy hunting cougar, and would like to harvest a trophy. Some either make a living or supplement their income from guiding cougar hunters. There are others who simply enjoy the chase, and are involved in pursuit with hounds without removing animals from the population. There are people who are only concerned with cougar when impacted by them financially, as is usually the case with livestock depredation, and want offending animals removed. There are those who enjoy seeing cougar, while others are content to just know they are there. Others value cougar for their intrinsic value, and believe cougar have their own right to exist, whether or not they provide a benefit to humans. The level at which cougar populations are managed must factor in biological, economic and social considerations.

Hunting

Cougar hunting has occurred in the area now governed by the state of Utah throughout recorded history. Bounty payments were first established in 1877 and reauthorized in

Figure 1. Cougar Taken in Utah by Bounty or for Depredation 1913-66.

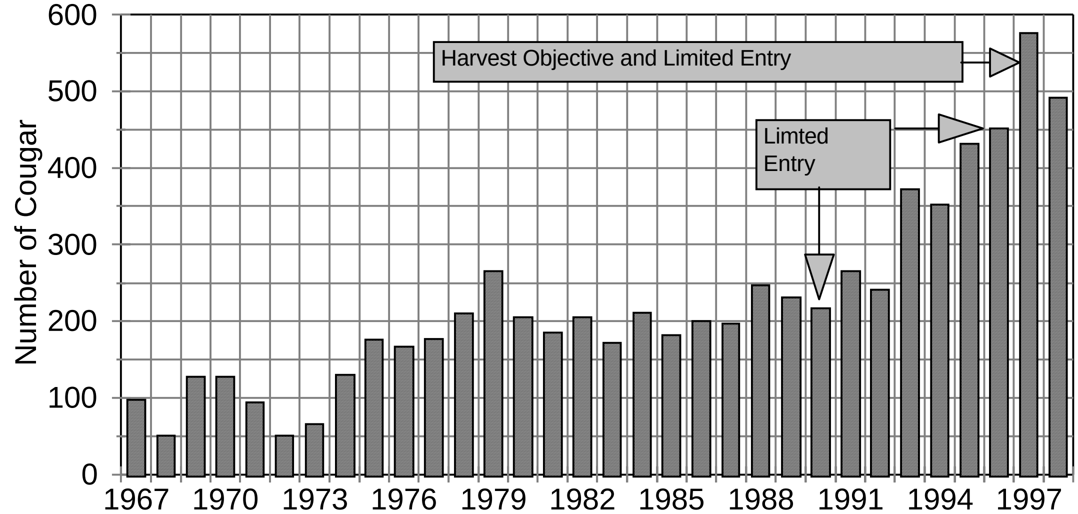


1896. Records indicate that bounties were paid for mountain lions from 1913 to 1924, 1926-28, and 1930-31. No bounties were paid from 1932 to 1943. Bounty payments for cougar ended in 1959. The number of cougar bountied ranged from 1 in 1926, to 349 in 1944, and averaged 77.2 per year (Figure 1). These figures represent a minimum take on cougar in these years, as not all harvested cougar were necessarily checked in for bounty payments. There are no records to indicate the number of people involved in cougar hunting during this period.

The number of cougar taken by sport hunters was estimated by conservation officers from the 1967-68 through the 1969-70 seasons. Beginning in 1970-71, hunters were required to complete a questionnaire, from which the number of hunters afield and cougar harvested were estimated. From the 1972-3 season to the present, hunters have been required to check in all harvested cougar with a UDWR officer and have a permanent tag attached. The sport harvest has ranged from a low of 51 in 1967-68 and 71-72 to a high of 576 in 1996-97 (Figure 2). The average harvest from 1967 to 1998 was 224. During the period when neither the number of permits nor harvest was limited in most of the state, 1967-89, the average harvest was 164 cougar. Statewide limited entry hunting was implemented in 1989-90, and ran through 1995-96. The average harvest during limited entry hunting was 333 cougar. In 1996-97, cougar harvest was controlled through a combination of harvest objective and limited entry hunting. The average harvest during this period was 534.

The number of hunters has increased steadily over the years, ranging from 92 in 1971-71,

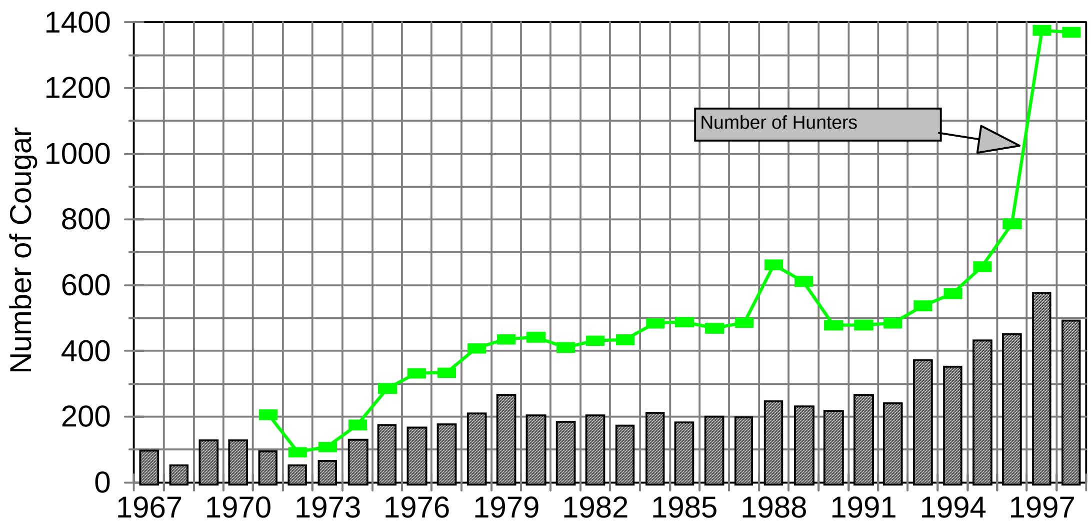
Figure 2. Sport Harvest of Cougar in Utah, 1967-98.



to 1376 in 1996-97. The average number of hunters from 1970-1998 was 501 (Figure 3). While the average number of hunters from 1970 to 1993 was 384, the average for the past 5 years was 953. Linear regression showed a significant relationship between the number of hunters and the sport harvest ($r=0.91$; $P=3.6^{e-11}$).

For the past two years, in addition to limited entry permits in selected units, an unlimited

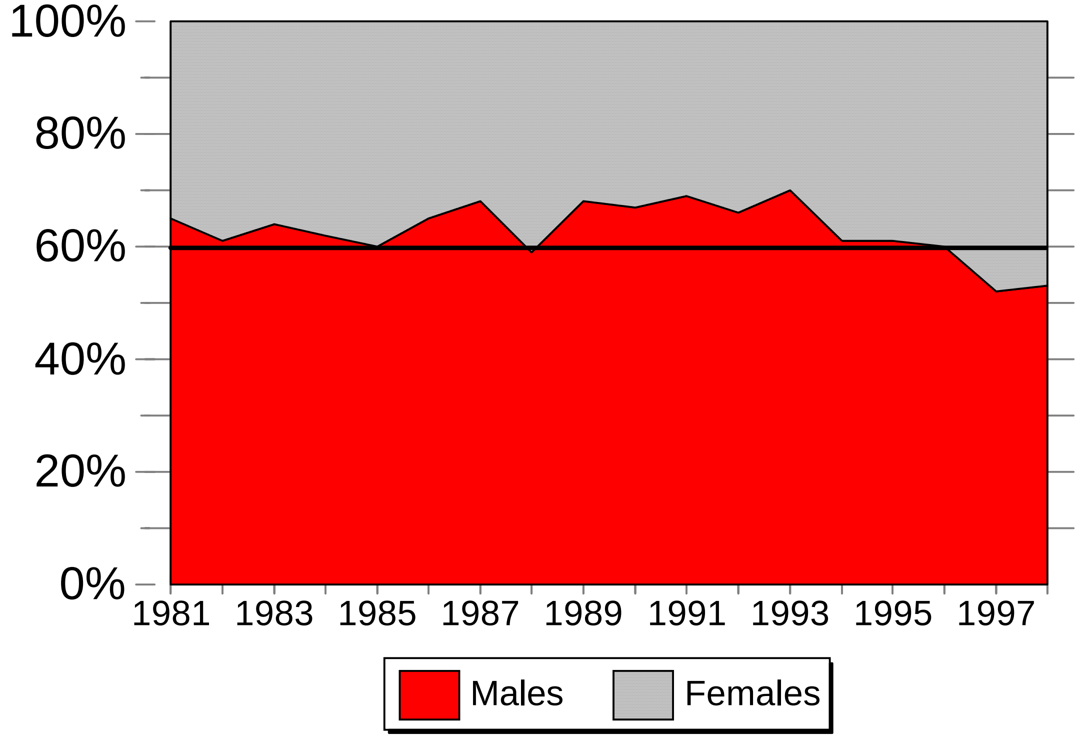
Figure 3. Sport Harvest of Cougar and the Number of Hunters in Utah.



number of permits have been authorized in harvest objective units. In 1996-97, 595 limited entry permits were issued; 509 were sold in 1997-98. Each applicant for a limited entry permit could indicate their top three choices, with permits going to those who listed the unit as their first choice first, and so on. A total of 4668 units were applied for in 1996-97, and 3184 in 1997-98. Considering that each person could apply for 3 units, a minimum of 1554 persons applied for a limited entry permit in 1996-97, and 1061 in 1997-98. Drawing odds average 1 in 11.3 for residents in 1996-97, and 1 in 12 in 1997-98. Odds for non-residents were 1 in 3.4 in 1996-97, and 1 in 3.3 in 1997-98. In 1997-98, a total of 671 harvest objective permits were sold. In addition, 190 of those permits were exchanged for a different unit.

Consecutive data on the sex ratio of the harvest is available from the 1980-81 season to the 1997-98 season. The percent of the harvest consisting of females has averaged 37.2%. Lindzey et. al. (1989) suggested that cougar populations were most sensitive to harvest of females. In order to maintain a stable population, they recommended that the female segment of the harvest should not exceed 40%. Utah cougar harvest has exceeded the 40% guideline 3 times since 1980-81 (Figure 4). Two of those occurred in the past two years, when the goal was to reduce cougar populations in management units

Figure 4. Sex ratio of cougar harvest in Utah, 1981-98.



with approved predator management plans. The percent of females in the harvest was compared for the 1996-7 and 1997-8 seasons to find differences in unit management type. The percent of females in the harvest was 46.6% in limited entry units, as compared to 48.3% in harvest objective units.

Beginning in 1995, a tooth has been collected from each cougar harvested. These teeth were sectioned and age of the cougar estimated by counting cementum annuli. Variation inherent in the aging process of cougar teeth could increase the size of confidence limits. The average age of cougar taken in 1995-96 was 3.5 years, and in 1996-97 it was 3.8. It dropped to 3.2 in 1997-98. The average ages of males were lower than females. Males averaged 3.5 in both 1995-96 and 1996-97, but declined to 2.8 in 1997-98. The average ages of females taken were 3.6 in 1995-96, 4.1 in 1996-97, and 3.7 in 1997-98. Analysis of variance showed a significant difference between years (Bates and Henry 1999). The only significant difference in ages between unit management type was found in the ages of females, with females taken in harvest objective units younger on average than those taken in limited entry units (3.6 yrs. in harvest objective units; 3.7 yrs. in limited entry units; $P<0.5$). Ages of cougar harvested ranged from less than one to over 21 years. Analysis showed a shift from animals in the 4 to 7 age classes to a higher preponderance of 1 to 3 old males in 1997-8.

Guiding

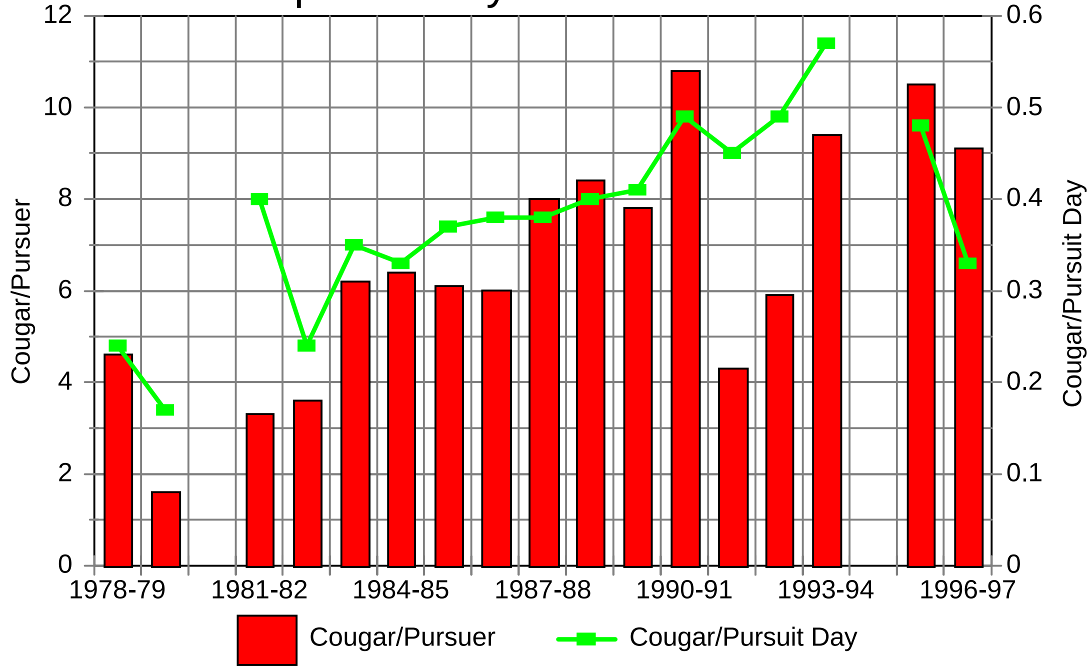
Although Utah does not regulate guides in the state, many hunters use guides to harvest mountain lion. Of 492 cougar harvested in 1997-98, 378 were taken with the assistance of a guide (76%). Non-resident hunters were more likely to use a guide than resident hunters. Ninety-four percent of successful non-resident hunters used a guide, while only 64% of successful resident hunters did. One-hundred and fifty-eight different guides were reported to have successfully guided a hunter. The average harvest per guide was 2.39 cougar. However, the majority guided one successful hunter. The highest total reported taken by one guide was 21 cougar. Twenty guides assisted at least 5 successful hunters.

Pursuit

Utah has offered a pursuit-only permit since 1978. This permit allows a hunter to chase, but not harvest cougar. The pursuit season runs concurrent with the regular season. A pursuit permit holder may hunt in both limited entry and harvest objective units. Many guides use the pursuit permit as a way to use their hounds with a client who has a kill permit for a given unit. Up until 1999, a pursuit permit holder could pursue both cougar and bear. A separate permit for each species became required January 1, 1999.

The number of pursuit permits sold has increased steadily over the years, ranging from 91 in 1979-80, to 638 in 1996-7. The average number of permits sold per year was 285. An average of 85% of permit holders pursued cougar. The average number of cougar treed

Figure 5. Cougar treed per pursuer and pursuit day in Utah. 1978-97.



per pursuer was 6.6, ranging from 1.6 in 1979-80, to 10.8 in 1990-1 (Figure 5). The number of cougar treed per pursuit day averaged 0.38, ranging from 0.17 in 1979-80 to 0.57 in 1993-94. This statistic may indicate population trend. Not every hunter with a kill permit necessarily intends to take a cougar every day they hunt. First time hunters with a guide generally intend to fill their permit as quickly as possible, but typically hold out for a larger trophy until they must stop hunting. Others who have taken a cougar in the past choose not to kill a mountain lion unless they find a large tom. However, every hunter, whether using a harvest or pursuit permit, intends to tree a cougar each time they hunt.

The effects of pursuit hunting on individual cougars are not understood. Some possibility exists for mauling of kittens less than six months of age (Lindzey et al. 1989). An attempt was made on the Boulder Mountains to determine the effect of prolonged or repeated chases on mountain lions. This study found a lowered plasma cortisol profile in cougar subjected to a simulated chase (Harlow et al. 1992). This has been interpreted as either a negative condition brought on by stress, or an adaptation that allows the mountain lion to adjust to higher stress levels. It should be noted that Utah's cougar population continued to either increase or maintain population viability while existing under a management system that allowed pursuit hunting. The stress associated with the fear of attack is part of the 'predator/prey' environment.

Livestock Depredation

Livestock depredation by cougar, particularly on domestic sheep, can be locally severe and depredation management is an important component of cougar management. Currently, under Wildlife Board policy, livestock producers can remove a cougar which “is harassing, chasing, disturbing, harming, attacking or killing livestock, or has committed such an act within the past 72 hours (UDWR 1998). Livestock producers are required to notify the Division after taking such action. If desired, they can purchase a cougar depredation permit for $25 and keep one pelt each year. In the past 5 years, 34 cougar have been taken and reported under this clause. Because of the secretive nature of the cougar, few incidents are handled in this manner. Some cougar mortalities may not be reported if the cougar was mortally wounded but escaped.

Livestock producers may also contact USDA-Wildlife Services for assistance in resolving depredation problems, and most incidents are handled in this manner. After receiving notification from the producer, reported kills are investigated by a Wildlife Services field agent. The Division is also notified. Kills that are confirmed are eligible for partial compensation, and lethal control on the offending animal is initiated. Shaw (1989) reported that multiple sheep kills are the rule, rather than the exception. An average of 37 cougar have been taken per year by field agents from 1917 to 1998 (Figure 6). This number has ranged from 5 in 1923, 1924 and 1974, to a high of 106 in 1964. The short term average from 1992 to 1998 was 43, ranging from a low of 27 in 1998 to 54 in 1995. The number of

Figure 6. Cougar taken in depredation situations by Wildlife Services (ADC).

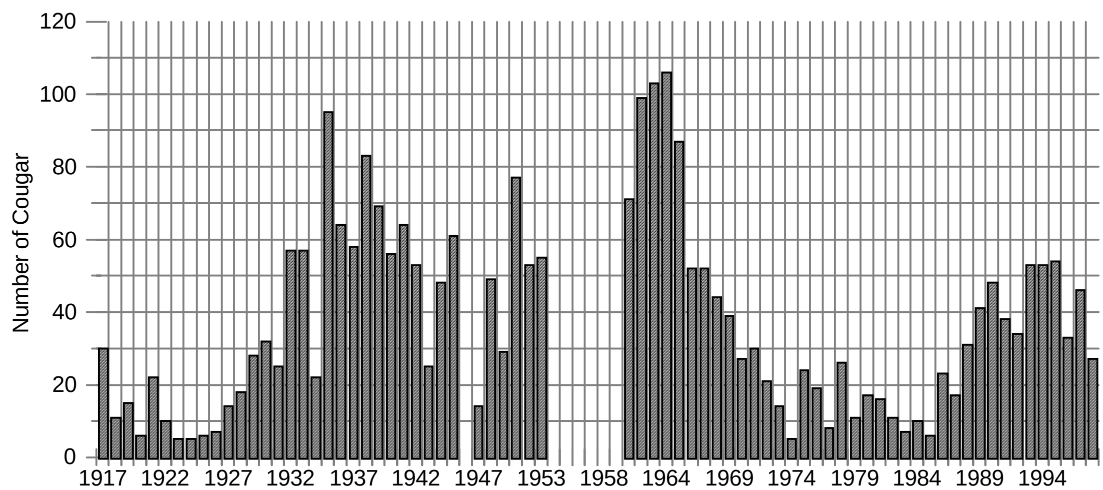
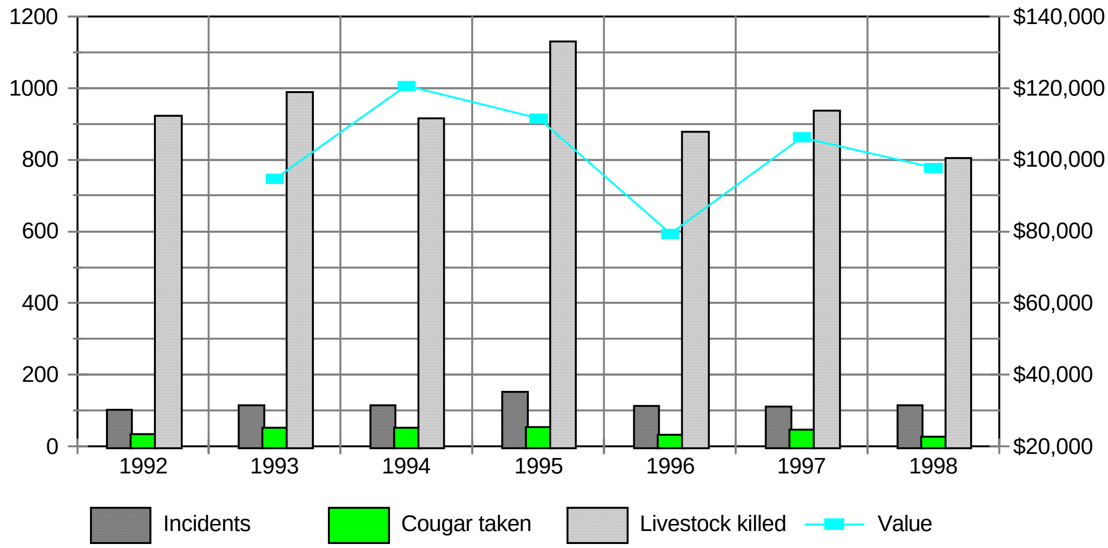


Figure 7. Livestock losses due to cougar depredation in Utah, 1992-98.



cougar depredation incidents averaged 117 per year (Figure 7). The average number of livestock killed by cougar was 939. The reported value of livestock lost averaged $101,657, and ranged from $79,277 in 1996, to $120,615 in 1994. Both confirmed losses of livestock and the number of cougar taken has declined for the past several years. Two factors possibly contributing to this reduction include an increased sport harvest and an increasing deer herd. From 1992 to 1998, 300 cougar were removed that were involved in 820 damage complaints (36.6%). Of the 243 cougar taken from 1993-97, 60% were removed with the aid of hounds, 36% with foot snares, 3% with foot-hold traps, and 1% were shot. Fifty-seven percent of these were males, and 43% were females. Over 73% of cougar taken for depredation were adults.

Confirmed livestock kills for sheep, cattle, and turkeys are eligible for partial compensation. To be eligible, depredations must be investigated by either a Division employee or Wildlife Services field agent and the operator must have paid his livestock assessment (head-tax) for the current and preceding years. From 1992-1997, the depredation fund for losses due to cougar and black bear paid up to 50% of the value of confirmed kills, up to a cap of $50,000. This was paid from license revenues received by the Division. The 1998 Utah State Legislature provided a one-time supplement of an additional $50,000 from the General Fund, which allowed full compensation, up to a cap of $100,000. The amount paid for livestock losses due to cougar averaged $40,148 per year from 1993-98, ranging from $33,134 in 1993, to $58,233 in 1998. The amount eligible exceeded available funds from 1995 to 1998. Operators received 36% of value in 1995, 47% of value in 1996, 30% in 1997, and 60% in 1998.

Predation by cougar on native wildlife, especially mule deer, has been a concern of sportsmen for years. Both species have evolved under this predator/prey relationship, which is part of the natural environment in Utah. Removal of cougar for the protection of native wildlife is a controversial subject. Current Wildlife Board policy recognizes that predator management is an important management tool for specific situations. This policy allows predator management plans to be prepared in specific big game management units that are 1) significantly under herd unit objective (at least 50% below objective) and 2) in a downward or stable trend. Predator management plans can also be prepared to protect reintroductions of big game into previously occupied habitat. Integral components of predator management plans typically include increasing harvest on cougar, and focusing efforts by Wildlife Services to remove coyote pairs in areas where big game young are born, before fawning season.

Human Safety Concerns

Human safety concerns regarding cougar in Utah must be considered. Significantly, no human has been killed by a cougar in the history of the state. One person was injured when the horse he was riding was attacked in the Book Cliffs in 1997, and stalkings have occurred. Most human safety concerns stem not from actual attacks, but from the threat of attack based on cougar living in close proximity to humans, perhaps becoming habituated to human activity. Torres et al. (1996) reported cougar pet depredation in California was significantly correlated with new housing development. Pet depredation areas were in the same regions where public safety problems occurred and reflected a radiation of human activity into cougar habitat. The USDA-Wildlife Services program, at the direction of the UDWR, removed 12 cougar from 1993-97 for human safety concerns. Eight of these were in 1997. Several other cougar were removed from urban areas by Division personnel and relocated to remote areas.

Beier (1991) reviewed records relating to cougar attacks on humans in the U.S. and Canada from 1890 to 1990 to determine historical trends and characteristics of victims and attackers. Nine attacks on humans were fatal and at least 41 non-fatal. Attacks increased from 1970 to 1990, when human use of cougar habitats also increased. Most victims were children (62%); the modal age class was 5-9 years. Of 34 child victims, 28% were alone, 50% were in groups of children, and 22% were with adults. Nine of 15 adult victims were alone. Half of 26 offending cougar were estimated to be 12-23 months of age. Over 57% of attacking cougar were markedly underweight. Beier postulated that an aggressive response by an intended victim may ward off an attack or repel an attack in progress.

Non-consumptive Use

People enjoy wildlife in many different ways. Some enjoy observing wild animals, some enjoy learning about them, some enjoy hunting them, and some enjoy the knowledge that they exist. Because cougar are so secretive, direct observations are rare. Some people participate in non-consumptive use of cougar by going to cougar habitat and observing cougar tracks or sign. Some people argue that pursuit hunting is non-consumptive. There are some people, however, who feel very strongly that it is wrong to hunt wild animals-or at least that it is wrong to do so for mere amusement or trophy, i.e. for sport. This group of people is in fact a large and growing portion of the public, so it is important that wildlife management professionals understand and respect their perspective.

What distinguishes members of this group from others is their belief that wild animals possess intrinsic value, and not only instrumental value. They believe, in other words, that wild animals are good in themselves and not merely interesting to observe or fun to hunt. Accordingly, we are required to respect the lives of wild animals-we are required to treat them as beings possessing dignity and worth, and not merely as a means to our own enjoyment, whatever form that enjoyment may take. This is why “nonconsumptive” wildlife users are often so strongly opposed to many traditional “consumptive” wildlife practices, such as sport hunting, hounding of black bear and cougar, bear baiting, and trapping.

This difference of opinion puts wildlife managers into an uncomfortable dilemma. They are legally mandated to manage wildlife that is “owned” by all the people, but in serving the wishes of one group of citizens they automatically disserve the wishes of the other group. In one way, the easiest solution would be to just ignore the wishes of one of the groups. Yet, this would be unfair and inappropriate. Hence, some accommodation of both points of view is necessary, even if neither group is completely happy with it.

The only feasible way of effecting a compromise is to divide up the pie, so to speak. For example, in one area of its habitat the pursuit and hunting of cougar might be allowed for the sake of the consumptive user group, while, for the sake of the noncomsumptive user group, in another area it might not be allowed even if there is no biological need to impose such a restriction, and even if the area is not already off limits to hunting because it lies within a national park or monument. Like all wildlife management decisions, this would be a political decision. After all, science does not dictate that animals be pursued or hunted, or that they not be, but rather inform us of potential consequences that will result from various management approaches.

Economics

The hunting and enjoyment of cougar in Utah generates the expenditure of funds that contributes to the state’s economy. Hunters and houndsmen must purchase the necessary permits to participate in hunting and pursuit of cougar. This provides the Division funds necessary to manage cougar. The sale of these permits produced an average of $132,506 from 1993-98 (Table 2). These dollars were then eligible to be used as a match for Federal Pittman/Robertson funds, which come from an excise tax on hunting equipment. This match is based on a 75:25 basis. When added to permit sales, this resulted in an average of over $530,000 being available to the Division on an annual basis.

Revenue generated to the state's economy was estimated using information from the *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (USFWS 1998). Those participating in hunting, pursuit, and non-consumptive enjoyment of cougar purchase equipment, food, lodging and other items. The average hunter in Utah spent $24 per day. It is not possible to estimate the amount of time non-consumptive users spent in recreational activities relating to cougar. Being a secretive animal, few are observed, and then for only brief moments. However, it should be noted that those who enjoy cougar for their intrinsic value do contribute to the economy when they participate in outdoor recreation. The amount of revenue generated in guide fees was estimated based on the assumptions that 96% of non-resident hunters and 22% of resident hunters use a guide, and that non-residents typically pay more for a guide ($3000) than do residents ($2000). Many resident hunters use guides who are friends who may only guide one or two persons per year. Non-residents typically use professional guides. Based on these assumptions, guide fees generated an estimated average of $1,046,408 to the state's economy annually (Table 3). Total estimated revenue to the state, combining agency revenue, guide fees, and hunting related expenditures, was estimated at an annual average of over $1,700,000.

Table 2. Permit revenue generated by the Utah Division of Wildlife Resources through cougar hunting.

	1993-4	1994-5	1995-6	1996-7	1997-8
Resident Limited Entry Permits	$28,652	$34,394	$37,932	$24,098	$22,098
Non-resident Limited Entry Permits	42,570	51,084	56,244	43,860	33,024
Resident Harvest Objective Permits				39,008	25,016
Non-res. Harvest Objective Permits				41,745	50,347
Harvest Objective Permit Exchanges				770	950
Non-res. Small Game License	6,600	7,920	8,720	12,880	13,080
Non-res. Habitat Authorization	825	990	1,090	1,691	1,717
Pursuit Permits	13,800	12,625	15,675	15,950	15,775
Livestock Damage Permit	275	275	75	175	50
Yearly Total	$92,722	$107,288	$119,736	$180,729	$162,057
Pittman/Robertson Funds (3:1 match)	$278,166	$321,864	$359,208	$542,186	$486,170
Grand Total	$370,888	$429,152	$478,944	$722,914	$648,227

Table 3. Estimated revenue generated by cougar hunting into the Utah economy, 1993-98.

	1993-94	1994-95	1995-96	1996-97	1997-98
Agency Revenue	$370,888	$429,152	$478,944	$722,914	$648,227
Guide Fees	692,560	831,160	915,600	1,475,640	1,317,080
Hunting Related Expenditures	116,712	134,040	145,440	205,128	178,592
Yearly Estimates	1,180,160	1,394,352	1,539,984	2,403,682	2,143,899

ISSUES AND CONCERNS **Cougar Discussion Group**
Regional Wildlife Managers
Regional Biologists

Issues and concerns with cougar management in Utah were identified by two separate groups. The Cougar Discussion Group met in September, 1998, and made a preliminary list. This list was then sent to regional wildlife managers along with the first draft of this assessment, who added their input.

The following issues and concerns have been identified:

Public Issues and Concerns:

- Effect of mountain lion population on human safety.
- Effects of mountain lions on prey populations.
- Impacts of mountain lions on livestock.
- Increasing sales of kill permits.
- Hunter desire to harvest trophy cougar.
- Increasing number of pursuit hunters, or too much pressure in a given area.
- Concerns for cougars as individuals.
- Public desire to manage cougar conservatively.
- Public concerns about sport hunting and methods used, e.g. hounds.
- Public's lack of understanding, or distrust of taking cougar to protect livestock or public safety.
- Guides are unregulated.

Management Issues and Concerns:

- Required to manage populations without reliable population estimator.
- Need to protect breeding females to avoid over-exploitation.
- Lack of data to document effects of cougar on prey; and effects of prey on cougar.
- Lack of understanding of cumulative effects of multiple prey and predator species.
- Cougar population estimation and research is difficult, time intensive, and expensive - inability to set up true experiment.
- Funding limitations.
- What are the effects of harvest strategies on population structure and lion social structure?
- What are the effects of cougar hunters using hounds on critical winter ranges when big game are stressed and vulenrable?
- Impacts of cougar hunters on roads (ruts, erosion, etc.).
- Identification of conflicts between big game and cougar hunters.

- Secretive and wide-ranging species - requires management of metapopulation.
- Need to manage on unit basis.
- Management units are too small to reflect actual population.
- Training needed to learn how to effectively use new technology to manage on metapopulation basis (GIS, GPS, DNA, etc.).
- Increased cooperation and coordination needed among states to manage metapopulations.
- Public knowledge is lacking and public perceptions are inaccurate about cougars.
- Inability of agency to let public know how problems are being addressed.
- Lack of understanding of predator/prey relationships by biologists results in conflicting information being given to the public.
- Tendency of divergent publics to proliferate their view without substantiation or representing the entire picture.
- Need to understand what “all” our publics think about agency’s cougar management.
- Biologists uncomfortable setting objectives due to lack of understanding about 1) public desires; 2) administration direction; and 3) lion numbers.
- Public’s tendency to use predation as a scapegoat and divert attention and efforts away from other problems, such as loss of habitat.
- Habitat quality and quantity decreasing annually.
- Need to address public safety concerns.
- Need to address livestock depredation on an individual basis.
- Funding for livestock depredation compensation.
- Researchers need to communicate and share data with each other. Look for ways to combine efforts to answer basic questions.
- How do agencies/society want to value cougar? A common agreement on valuing cougar populations is the bottom line.

GOALS AND OBJECTIVES

The goals and objectives of the Utah Cougar Management Plan are as follows:

GOAL: Maintain a healthy cougar population within existing occupied habitat while considering human safety, economic concerns, and other wildlife species.

DEFINITION: A healthy cougar population is one that: 1) maintains a reasonable proportion of older age animals; 2) maintains breeding females; 3) has healthy individuals; 4) is in balance with its natural prey; and 5) maintains genetic variability.

OBJECTIVES:

A. Maintain current cougar distribution, with a reasonable proportion of older age animals and breeding females, balancing population numbers with other wildlife species, through the year 2009.

The following list of performance targets will apply to all units, except those being managed under a predator management plan. Data will be monitored on a regional and statewide basis, excluding units with a predator management plan.

<u>Performance Targets:</u>

1. The percent of animals in harvest over 6 years of age averages 15% or greater.
2. Total adult survival of 65% or more.
3. The percent of females in the harvest is less than 40%.
4. The number of cougar treed per hunter day averages 0.38.
5. Reduce the number of units being managed by a predator management plan.

<u>Strategies:</u>

1. Develop unit management plans that balance cougar numbers with available prey and habitat;
2. Develop harvest regulations that maintain a reasonable proportion of older age animals and maintains breeding females;
3. Monitor cougar health and disease and take necessary actions to maintain healthy individuals;
4. Implement Predator Management Plans in accordance with the Division's policy on *Managing Predatory Wildlife Species*, dated January 19, 1996, on big game units where population numbers are 50% of objective and in a

stable or downward trend, or in areas to protect recently reintroduced prey populations;

5. Fund research projects to learn more about the relationship between cougar and their prey, and methods to support measuring and accomplishing goal;
6. Implement research findings on population monitoring to determine population trend, composition and relative abundance on a unit basis;
7. Monitor recreational utilization of cougar and develop hunting, pursuit and control regulations that minimize pain and suffering;
8. Secure funding to accomplish essential elements of Cougar Management Plan;
9. Coordinate and cooperate with other states, provinces and researchers.
10. Obtain public views on cougar management and educate the public on cougar biology and management;
11. Support legislation to regulate large mammal guides;
12. Provide training to agency biologists and I&E personnel on predator biology to ensure consistent message is being given to the public and to improve cougar management;
13. Determine the definition of 'refugia' and evaluate the utility of establishing refugia in the state.

B. Minimize the loss in quality and quantity of existing critical and high priority cougar habitat through the year 2009.

<u>Performance Measures:</u>

1. Number of acres of high, medium and low cougar habitat.
2. Number of habitat enhancement projects completed.

<u>Strategies</u>:

1. Protect critical and high priority mule deer habitat quality and quantity through commenting on land management agency development proposals and developing appropriate mitigation;
2. Improve critical and high priority habitat through a minimum of 5 habitat enhancement projects per year, focusing on habitat limiting prey and travel corridors;
3. Develop GIS map of the state depicting cougar habitat and identifying defacto refugia and habitat connectivity.
4. Work with land management agencies to protect migration/travel corridors in order to maintain genetic diversity within the statewide meta-population;

C. Reduce the risk of loss of human life and reduce chances of injury by cougar through 2009.

Performance Measures:

1. Number of people injured by cougar.
2. Number of incidents reported.

Strategies:

1. Develop, obtain approval, and implement *Managing Nuisance Cougar* Policy, which establishes guidelines to handle problem cougar on an individual basis;
2. Educate the public about the dangers associated with recreating in cougar habitat and how to avoid problems;
3. Educate landowners on the dangers associated with living in cougar habitat and how to reduce likelihood of encounters.

D. Maintain a downward trend in the number of livestock killed by cougar.

Performance Measures:

1. Number of calves, sheep, goats and other livestock killed by cougar.

Strategies:

1. Remove depredating cougar by targeting offending individuals in accordance with Memorandum of Understanding with Wildlife Services signed in 1988;
2. Fund research to develop animal husbandry methods that reduce conflicts;
3. Educate livestock operators on best management practices for reducing potential for cougar depredation;
4. Secure funding to continue livestock depredation payments from both the general fund and Wildlife Restricted Account at current levels.
5. Maintain cougar population structure less likely to depredate on livestock.

E. Maintain quality recreational opportunity for a minimum of 800 persons per year through the year 2009.

Performance Measures:

1. Number of limited entry cougar hunters.
2. Number of harvest objective cougar hunters.
3. Number of cougar pursuit hunters.

4. Number of non-consumptive recreators who buy a Heritage Permit and indicate a cougar emphasis.

Strategies:

1. Maintain recreational hunting and pursuit as management tools;
2. Increase non-consumptive participation in cougar mangement activities.

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