BEHAVIOR OF HIGH RISK MOUNTAIN LIONS

IN

BIG BEND NATIONAL PARK, TEXAS

Final Report

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EXECUTIVE SUMMARY

The National Park Service (NPS) is responsible for protecting natural ecosystems as well as the natural components of these systems, including predators. At the same time, the NPS has a responsibility regarding visitor safety, which might be threatened by such wildlife species. The purpose of this research project was to provide and analyze scientific data as a basis for management decisions of the NPS.

At Big Bend National Park, fifteen incidents have occurred in the last five years, in which mountain lions *(Felis concolor)* approached or showed aggression toward humans (Table 2). Of these encounters, two were attacks resulting in human injury, while one resulted in injury of a pet dog. In two incidents, native prey (javelina) were pursued in the presence of humans. In thirty previous years (1953-1983), at least thirty-eight occurrences of mountain lions approaching humans were reported, although not fully documented (Table 1).

In eight western states, serious encounters have involved primarily young male mountain lions and children (less than 19 years). In five of six documented cases, male mountain lions were involved in attacks (Tables 2 and 3). All reported cases involved mountain lions less than two years old. Seven of nine humans attacked by mountain lions were less than ten years old. One adult woman was attacked from behind when she fled from a mountain lion. A teenager was attacked and killed while jogging.

Our working hypothesis, developed from examination of the records, was that young male mountain lions are more likely to cause conflict than females or adult males. Furthermore, we hypothesized that adult females would avoid areas of high recreational development except during seasons when nutritional demands compelled them to use such areas. The explanation would be that a) adult females have stronger motivation for killing prey when their litters are still dependent on the mother for food, yet are close to adult size, and b) prey are attracted to permanent water sources near areas of high recreational development. An alternative hypothesis was that winter and spring represent nutritional stress periods when mountain lions are more likely to need prey resources available in the Chisos Basin, an area of high prey productivity as well as high recreational development.

During this 2-year study (Ruth 1991), five female and three male mountain lions were tracked by radio telemetry. The sampling schedule involved searches daily by foot and a vehicle, weekly by airplane and monthly 3-day continuous monitoring of a single animal. Analyses included data from previous studies (McBride and Ruth 1988; Waid 1990), and utilized the GRASS Geographic Information System.

Although subadult male mountain lions have been responsible for most conflicts with humans, many young cats never become involved in such encounters (Ruth 1991). Of six subadult males studied, three were removed due to encounters with humans or a pet (Table 4). Seven young females dispersed or died without serious incident, although one approached humans (Table 6). Six adult females (Table 6) and three adult males (Table 4) did not encounter humans.

Home ranges of adult males overlapped several females (Figure 3). Females with ranges including the Chisos Basin had smaller home ranges than females in the desert (Figure 4; Waid 1990), possibly indicating greater prey availability in the Basin (Ruth 1991). Young females dispersed to areas more distant (Figure 6) than did young males (Figure 5).

Two adult females (F05, F07) were located frequently in the Chisos Basin during four winter seasons when their litters were over a year old (Table 7). During 3-day monitoring periods, the Basin female (F05) spent significantly more time in highly developed areas during winter (1990) and spring (1989) than in summer and fall (Ruth 1991). This female was more likely to be near the Basin campground and lodges at night than during the day (Figure 12) (Ruth 1991). In contrast, locations of F05 during previous (litterless) years, did not show such shifts into areas of high recreational development during winter and spring (Figure 15).

In contrast to her mother, a subadult female (F22) did not avoid the Basin campground and lodge vicinity during the day. During one 3-day sample, she fed from her mother's carcass near the Basin amphitheater. Over the next four months, she gradually moved from the Basin (Figure 13).

In the area of high recreational development, clusters of mountain lion locations occurred near drainages, thick vegetation and ridges (Figure 14). Reported incidents have occurred near such features in the Basin campground, the Laguna and Boulder Meadow campsites, and on the Basin loop and Lost Mine Peak trails.

Mountain lions were attracted to humans by (a) children unattended by an adult, (b) a pet dog chained at night in the campground, and (c) native prey possibly attracted to refuse, pet food, water and green vegetation near campsites and residences. Deterrents directed toward aggressive mountain lions included assertive behavior by adults who variously shouted, threw rocks, kicked at a mountain lion from lower branches of a tree, picked a child up off the ground, and one who brandished an emergency flare. A method of aversive conditioning (shotgun-delivered rock salt) was attempted on one mountain lion, but failed to prevent it from again approaching humans.

Ultimately, full achievement of NPS responsibilities lie in being able to predict lion activity and respond appropriately to ensure the safety of both park visitors and the lion population. Periods of high risk from juvenile mountain lions using the Chisos Basin can be predicted to occur 9-18 months after birth. Such periods appear least likely in summer since six of seven recorded litters were born between August and February. During such risk periods, priority should be given to interpretive programs, radio-collaring subadults and monitoring locations of mountain lions in the Basin. Trail closures may be necessary for transition periods when subadults are in the process of dispersal. During such transition periods, subadults are more likely to encounter humans. Useful educational channels were the park newspaper, ranger talks and signs at trailheads.

A flow chart of recommended actions in the event of a reported lion attack is included, yet a proactive rather than reactive policy is recommended (Ruth 1991). This would involve (1) trail modifications to reduce risk near drainages, ridges and thick vegetation, (2) education regarding protection of children and pets, (3) reduction of attractants for prey near campsites and residences and (4) monitoring of mountain lions that use the Basin developed area (at least two females, two males and their offspring). Such monitoring would identify estrus, breeding, and denning periods, from which high-risk dispersal periods would be calculated.

While this study has revealed much in relation to the stated hypotheses, there remain certain areas of mountain lion ecology, which are not well understood and could have important management implications. Broader interrelationships should be investigated such as mountain lion dependency on prey species whose numbers, movements, and availability may be affected by regional rainfall patterns. Prey and predator depend upon the primary productivity of vegetative communities for nutrition, cover and other benefits. However, effects of human disturbance, succession, and fire on vegetation in mountain lion habitat is unknown and needs to be investigated.

Big Bend National Park now has a long-term data set that is rare and valuable in its potential to address questions of importance to predator populations that may be vulnerable due to genetic isolation. From this substantial beginning, an opportunity exists to develop a comprehensive understanding of reproduction, dispersal, immigration, tenure of home ranges, mating patterns, and genetic variability. It would be a great loss if the continuity of data collection is not maintained. Such baseline information promises to be extremely important in assessing impact of future management decisions.

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Acknowledgments

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Introduction

Large predators such as mountain lions (*Felis concolor*) are an inherent wildlife value to national parks. Since few parks are large enough to maintain viable populations of large predators solely within their boundaries, this component of biological diversity is often the first to disappear (Newmark 1986). Resulting imbalances in plant/herbivore relationships can greatly reduce stability of the system and change native communities (Terborgh 1974). To many visitors, large predators symbolize the wilderness they seek to experience

However, predators in parks can present risks to domestic animals and untrained people. Ranchers adjacent to protected areas express concern over mountain lion predation on domestic livestock (Estes 1990; Smith, et al. 1988). A proactive policy of public education has been effective in reducing the frequency of injuries to campers due to bears (Herrero 1985). Innovative approaches to aversive conditioning have been suggested to reduce attacks on humans by tigers (Sunquist and Sunquist 1988).

Records of reported encounters with mountain lions in Big Bend National Park (BBNP) indicate that interactions have occurred for over 30 years (Table 1). Within the last seven years, three incidents resulted in injury to two humans and one dog (Table 2). It is difficult to say whether the frequency of attacks has increased in recent years, because the visitation rate and documentation of incidents has also increased.

Seven reports of mountain lion attacks on humans from other states (Table 3) suggest some common factors. All mountain lions identified after attacks on humans or dogs have been young, estimated as less than 2 years old (Tables 2 and 3). Six of seven mountain lions involved in attacks documented in BBNP and other states have been males. In the case of a female mountain lion that was killed in association with an attack at the Flathead Indian Reservation, Montana, it was uncertain whether the female had actually made the attack or whether another mountain lion was involved. Six of eight human victims were less than 10 years old. One adult woman was attacked from behind reportedly when she turned away excitedly. A teenager was attacked and killed while jogging.

From examination of the records, our working hypothesis was that young male mountain lions were more likely to cause conflict than females or adult males. Furthermore, we hypothesized that adult females avoided areas of high recreational development except during seasons when the nutritional demands of their year-old litters compelled them to hunt near permanent water sources near areas of high recreational development. An alternative hypothesis was that winter and spring represent a seasonal bottleneck when mountain lions are more likely to be in the productive Chisos Basin where high recreational development exists.

The purposes of this project included (a) evaluation of factors that influence mountain lions to behave in a manner that increases probability of adverse interactions with humans, (b) monitoring of the spatial distribution of mountain lions occupying areas of high recreational development in BBNP, (c) compilation of existing information requested by decision makers involved in management of mountain lions in BBNP, and (d) interface with the interpretive program at BBNP.

The project produced 8 quarterly reports describing the monthly movements and activities of mountain lions, a notebook of compiled information (Compendium II) and a master's thesis (Compendium I). This final report presents a concise summary of information from which we intend to prepare manuscripts for publication in refereed journals. Since the relevant data have been collected during four distinct phases (Davin 1989; McBride and Ruth 1988; Ruth 1991; Waid 1990), manuscripts will be coauthored.

Table 1. Mountain lion approaches reported at Big Bend National Park, 1953 through 1983.

Date	Location	Object of Approach	Effect	Mountain lion
01/09/53	Basin campground	canned ham	carried it away	adult
04/14/53	Lost Mine trail	man	grabbed pant leg	
04/17/53	Concession area	deer	chased	
05/05/53	Concession area	deer	feeding on kill	
08/10/57	Juniper Flat	dog	chased	adult
10/09/57	South Rim trail	dog	followed	
10/12/57	Lost Mine trail	human	approached closely	adult
11/13/57	Lower Basin	human	approached	adult
12/17/57	Basin cabin	near door	lying nearby	adult
12/26/57	Juniper Flat	humans	followed closely	
12/26/57	Casa Grande	humans	approached closely	large
12/27/57	Lost Mine trail	humans	ran toward	large
06/18/60	Boot Spring corral	burro	scratched face, legs	
07/17/75	East of K-Bar	javelina	killed	
10/24/78	Boquillas Road	deer	chased	
12/17/78	Panther Junction	deer	on kill	
11/11/78	Lost Mine trail	boy	ran toward	
07/03/78	Laguna Meadow	boy	"attacked"	
12/08/78	Juniper Flats trail	humans	followed	
01/10/79	Laguna Meadow	human	approach	
02/04/79	K-Bar	human	followed	
1979	Laguna Meadow trail	horses	followed	
01/1079	Laguna Meadow	humans	followed	
1979	Laguna Meadow trail	human	followed	
1979	Basin campground	human	approached	
1979	Mt. Emory campsite	boot	carried it away	
1979	Basin corrals	water	drinking	young
1979	Panther Junction	dog	attacked	old
05/15/80	Chimney trail	human	followed	
1980	Basin residences	dog	attacked under vehicle	small
12/19/81	Green Gulch	coyote	chase	
07/25/81	Lone Mountain	human adult	chase	
01/29/83	Boulder Meadow	deer	chase	
02/19/83	Maple Canyon	small animal	on kill	
07/17/83	Boulder Meadow	humans	watched	
08/06/83	Window trail	horses	followed	
08/08/83	Basin campground	boys	followed	
08/09/83	Basin horse corrals	horse	watched	

Table 2. Mountain lion approaches documented at Big Bend National Park, 1984 through 1990.

Date	Location	Object Approached		Effect	Mountain Lion		
		Type	Age (yr)		Age (yr)	Sex	Identity
04/04/84	Laguna Meadows	woman	>20	knocked down	<2		
05/31/84	South Rim trail	humans		approached			
07/12/84	South Rim trail	javelina		stalked			
08/02/84	Basin Loop trail	boy	8	injured	2	male[a]	
04/19/87	Basin Loop trail	woman	31	injured	1.5	male	M12[b]
02/27/88	Panther Junction	javelina		attacked	>2[c]		
05/05/88	Government Spring	woman	28	watched	1.7	male	M18[d]
03/03/90	Boulder Meadows camp #4	man	26	climbed tree	1.3[e]		
03/11/90	La Paloma ridge	man	>20	approached	1.3		
03/19/90	Basin Loop trail	boy, woman	3 >20	crouched, watched	1.3	male	M21[f]
04/24/90	Basin residences	children		watched	1.3	female	F22[e]
04/19/90	Basin amphitheater	mountain lion	11	fed on carcass	1.4	female	F22[e]
05/17/90	Pine Canyon camp	humans	>20	moved through camp	1.4	female	F22[e]
06/09/90	Pine Canyon camp	humans	>20	moved through camp	1.5	female	F22[g]
06/27/90	Basin campground	neutered dog		attacked	1.5	male	M21[h]

[a] Details are described by Pence et al. (1986). The mountain lion was killed and verified as the attacker due to human hair in the gastrointestinal tract. Age was estimated based on little tooth and pad wear.

[b] He was killed after he was trailed by dogs from the attack site (Davin 1987).

[c] Since the chirping of kittens was heard nearby, this was possibly an adult female. Although a nearby drainage was repeatedly checked for sign, there was no further evidence of mountain lions in the area.

[d] He continued to approach a vehicle even after sprayed with rock salt from a gun, so he was captured and translocated to a captive breeding program in Florida (McBride and Ruth 1989).

[e] Described in Ruth (1991).

[f] He was collared after dogs followed the trail from the site of the encounter (Ruth 1991).

[g] She did not cause any negative encounters and dispersed to south of the Chisos Basin (Ruth 1991).

[h] He was separated from the dog only after visitors placed an emergency flare near his head. He continued to approach the vehicle in which the dog was placed (Ruth 1991). He was trapped the next morning and relocated within the park to McKinney Springs. He dispersed and was found dead on the Rosillas Ranch.

Table 3. Mountain lion encounters reported outside Texas.

Date	Location	Object Approached		Effect	Mountain Lion	
		Type	Age (yr)		Age (yr)	Sex
1952[a]	Idaho	child man				
1974[b]	Arroyo Seco, New Mexico	boy	8	killed	< 2	
1986[c]	Caspers Wilderness Area, Calif.	boy girl	6 5	injured injured	unknown <2	 male
1989[d]	Flathead Indian Reservation, Mont.	boy	5	killed	<2	female
1989[e]	Canyon Lake, Ariz.	boy	5	injured	<2	
1990[f]	Coal Creek Canyon Boulder, Colo.	3 dogs 3 llamas		killed killed	unknown	
1990[g]	Lake Blaine, Mont.	dog		killed	<2	male
1990[h]	Glacier National Park, Mont.	boy	9	injured	<2	male
1991[i]	Colo.	teenager	18	killed	unknown	

[a] Peterson (1952)

[b] Reported in Audubon Magazine, March 1988

[c] Incident report, County of Orange, Environmental Management Agency, Parks and Recreation, 10852 Douglass Road, Anaheim, Calif. 92806.

[d] Reported in the Spokesman-Review, Thursday, September 14, 1989, Spokane, Wash. page A1

[e] Reported in the Phoenix Gazette, May 17, 1989, page A-1.

[f] Reported in the Bryan-College Station Eagle, Monday, February 26, 1990, page 4A.

[g] Reported in the Hungry Horse News, Montana, July 12, 1990

[h] Reported in the Hungry Horse News, Montana, July 26, 1990

[i] Reported in The Houston Post, Texas, February 24, 1991, page A-16

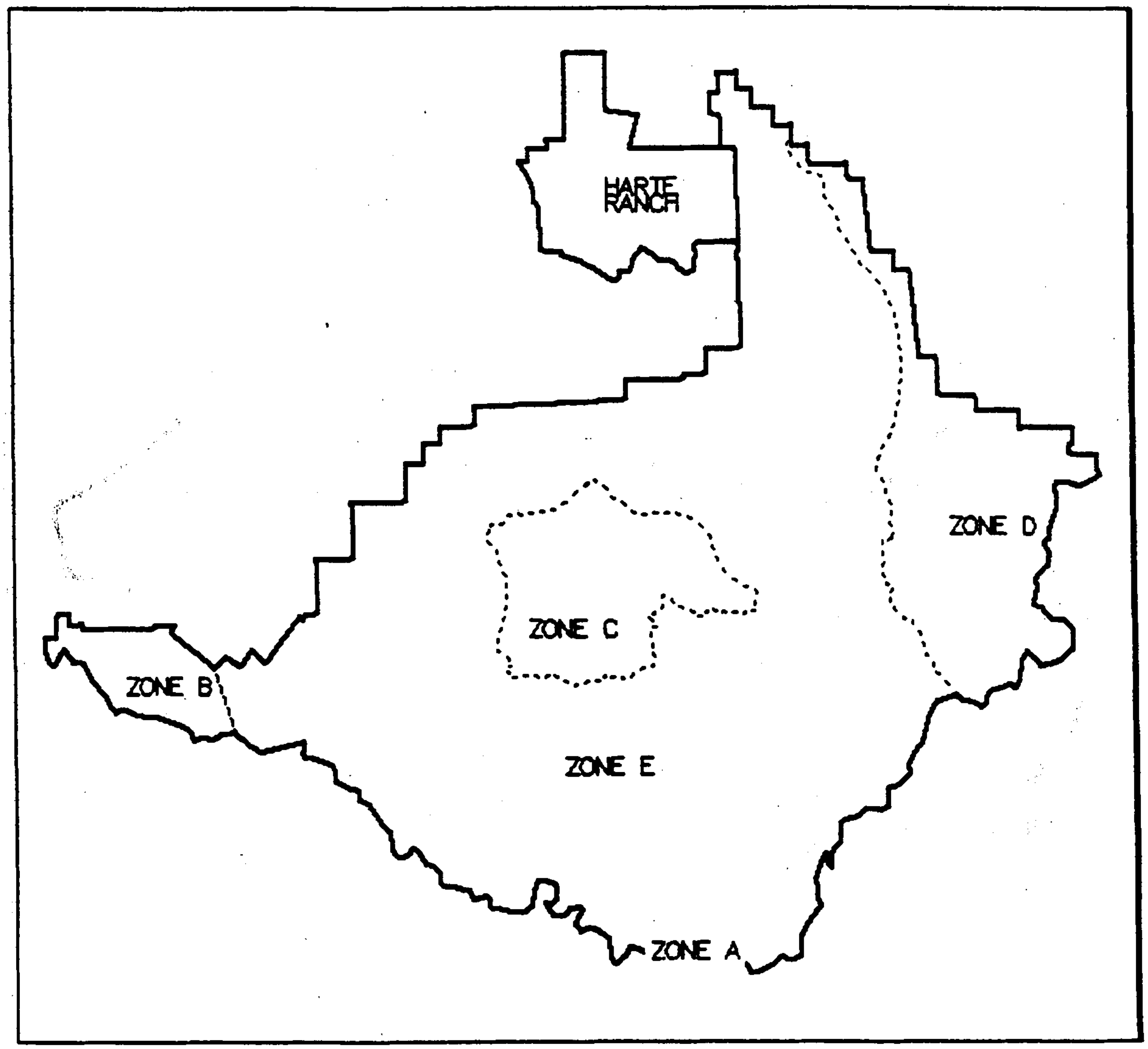

Figure1. Management zones in Big Bend National Park. Zone C is the Chisos Mountains Management Zone.

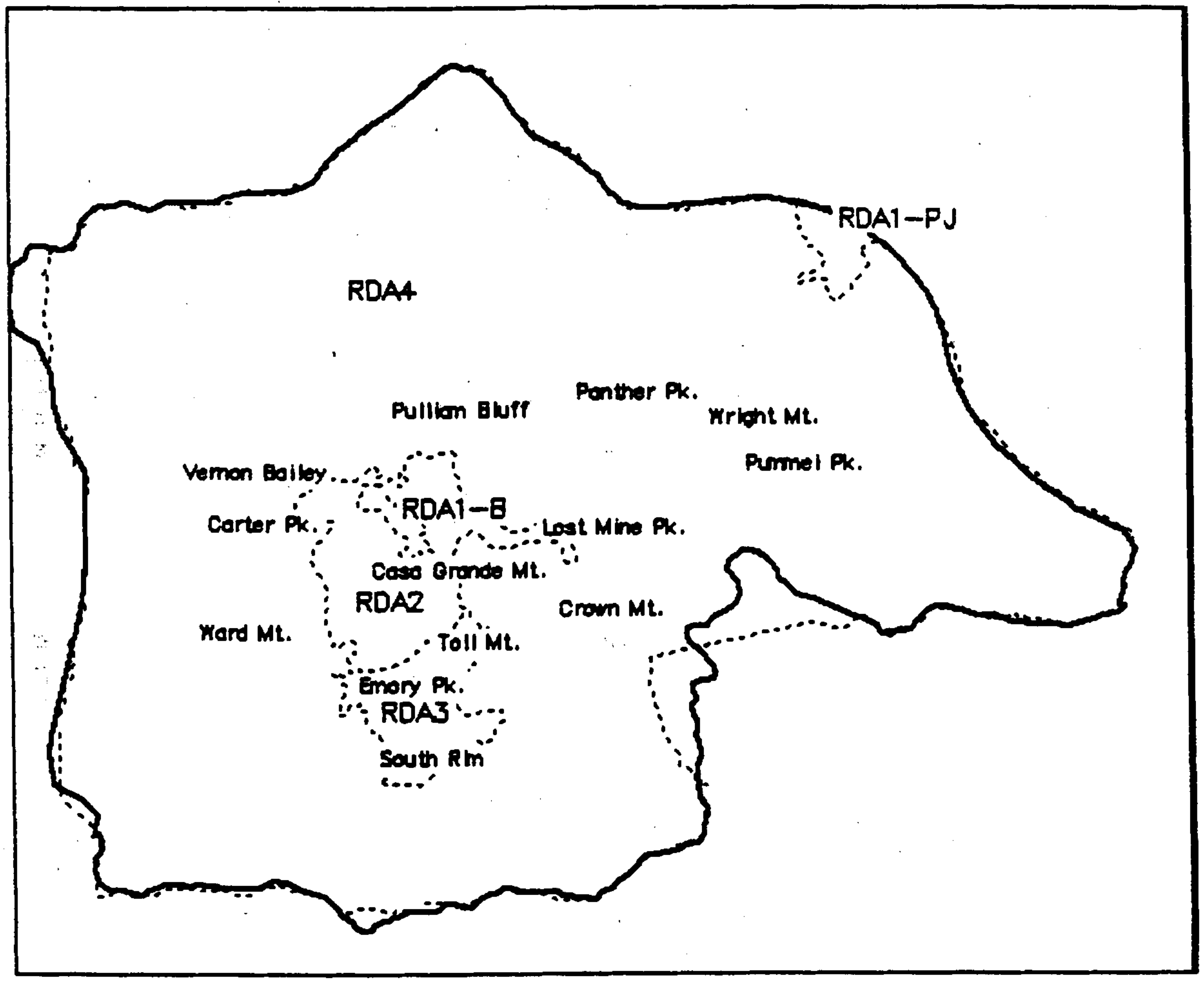

Figure 2. Recreational development areas in the Chisos Mountains Management Zone. Codes represent the areas of intense recreational development in the Chisos Basin (RDA1-B) and Panther Junction (RDA1-PJ), the high development (RDA2), moderate development (RDA3) and low development (RDA4).

Methods

Subjects

Mountain lions were captured in box traps or they were treed using trained dogs, as described by Waid (1990) and Ruth (1991). They were immobilized for attachment of a radio collar and for physical measurements. Adults were recollared after about 2 years when possible, due to the expected battery life. When individuals less than 2 years were collared, they were recollared at about 2 years of age when they typically would have reached adult size. Capture effort by Ruth (1991) and McBride and Ruth (1989) was focused on the Chisos Mountains. Waid (1989) also captured animals in the desert lowlands.

A total of 9 males have been collared since 1983 (Table 4). One of these males (M14) was alive and in the park at the initiation of this project; another adult (M19) and subadult male (M21; son of F05) were collared during the project (Ruth 1991).

A total of 13 females have been collared since 1983, including 7 young (Table 5) and 6 older animals (Table 6). Four of these were alive at the initiation of this study, although one (F16) had dispersed from the park and another (F17) had dispersed from the Basin to an area relatively inaccessible for radio-telemetry from the ground. Two adult females (F05, F07) that used the Chisos Mountains were recollared during this study. Subadult females that were the offspring of F05 (F22) and F07 (F20) were collared during this study.

Data Collection

The sampling schedule during this study involved daily searches from a vehicle, weekly searches by airplane and monthly 3-day continuous monitoring of one focal animal (Ruth 1991). Continuous monitoring was necessary because daily samples were biased by time of day. Data recorded for each location, determined by radio-telemetry, followed standard procedures (Kenward 1987; Logan, et al. 1986) and included UTM location of the mountain lion, compass bearings from known locations on roads or trails, time, quality and variation in the signal pulse during 60 seconds. Telemetry error was estimated for ground (91 $\pm$ 45 m) and aerial locations (264 m $\pm$ 54 m) by placing radios in locations unknown to the receiver operator.

Focal animal samples were obtained during 15 months, including 11 samples from the Basin female (F05) and four samples from her daughter (F22) after the Basin female died (Ruth 1991). The focal animal sampling technique involves data collection regarding the behavior of one animal (Martin and Bateson 1986). Locations were recorded at 15-min intervals for 72 continuous hours (3 days). This was accomplished by two teams of 2-4 people stationed at sites where the intersection of bearings was not too acute. To avoid bias in the start times, focal animal samples were scheduled at least two weeks previously. On the morning of the starting date, location of the mountain lion was determined by aerial telemetry, and the sample started as soon as the teams could get in position. Telemetry error from a moving signal was estimated by tracking a radio attached to the leg of a hiker (445 $\pm$ 280 m; range 20-880m).

The sampling schedule for other studies differed. During 1984-1985, Waid (1990) conducted daily ground searches and aerial searches during three periods of about 20 days (March/ April, July/August, November). During 1986-1987, searches were made primarily from the ground and were less frequent due to other commitments of park personnel (Davin 1987; 1989). Ground searches were made on a daily basis and aerial searches as needed (13 times) during 1988 (McBride and Ruth 1988).

Analyses

Analyses were performed on three data sets, including (1) total recorded locations for all mountain lions, (2) tracks from 3-day focal animal samples, and (3) seasonal changes in locations of the two adult females that use the Chisos Basin most frequently. Analyses included data from previous studies (Davin 1989; McBride and Ruth 1988; Waid 1990) as well as Ruth (1991). These data are on file at BBNP (Compendium II).

Table 4. Chronological record of male mountain lions monitored in Big Bend National Park.

Identity	Date	Occurrence	Age[a] (yrs)	Weight (lb)	Reference
M01	12/25/83	Collared in Chisos window	1	80	Pence et al.(1986)
	03/1984	Trapped, died outside park	2		Pence et al.(1986)
M09	03/07/84	Collared in Grapevine Hills	7	123	Pence et al. (1986)
	08/1985	Natural death outside park	8		Pence et al. (1986)
M10	12/1983	Born of F07	0		Pence et al. (1986)
	11/10/84	Collared in Green Gulch	1	66	Pence et al. (1986)
	04/1985	Recollared	2.4	60	Pence et al. (1986)
	04/1985	Disassociated from F07			Pence et al. (1986)
	10/1985	Dispersed	1.8		Ruth (1991)
	1986	Trapped, died outside park	3		Pence et al. (1986)
M12	01/1986	Born of F07	0		Davin (1989)
	01/24/87	Collared	1	70	Davin (1987)
	06/29/87	Renamed ML3			Davin (1987)
	04/1987	Disassociated from F07			Ruth (1991)
	04/17/87	Attacked woman-Basin Loop			Davin (1987)
	04/19/87	Killed by Ranger	1.3		Davin (1989)
M13	02/12/87	Collared in Rough Hills	7	110	Davin (1989)
	07/21/87	Died in Panther Canyon			Davin (1989)
M14	02/14/87	Collared below Todd Hill	3	90	Davin (1989)
	08/03/88	Recollared	4	99	Ruth (1991)
M18	08/1986	Born of F11			McBride and Ruth (1988)
	02/21/88	Collared	1.6	92	McBride and Ruth (1988)
	03/23/88	Disassociated from F11	1.7		McBride and Ruth (1988)
	05/05/88	Approached visitor	1.9		McBride and Ruth (1988)
	05/26/88	Relocated to captive breeding program in Florida	1.9	74	McBride and Ruth (1988)
M19	01/08/90	Collared in Pulliam Reach	5	173	Ruth (1991)
M21	12/1989	Born of F05	0		Ruth (1991)
	03/19/90	Watched hikers-Basin trail	1.3		Ruth (1991)
	03/20/90	Collared in Basin	1.3	61	Ruth (1991)
		Disassociated from F05			
	06/27/90	Attacked dog in Basin camp			
		Relocated to McKinney Spr.	1.5	52	Ruth (1991)
	07/21/90	Died in Rosillos Mts.	1.6		Ruth (1991)

[a] Age was estimated from pelage characteristics and tooth wear or replacement (Ruth 1991) and is generally within a 1-3 yr range of error.

Table 5. Chronological record of young female mountain lions monitored in Big Bend National Park.

Identity	Date	Occurrence	Age[a] (yrs)	Weight (lb)	Reference
F2	01/02/84	Collared near Chisos window	2	81	Pence et al. (1986)
	02/1984	Trapped, killed outside park	2		Ruth 1991
F3	01/02/84	Collared near Chisos window	3	90	Pence et al. (1986)
	04/10/84	Dispersed to Sierra Ponce			Pence et al. (1986)
	04/14/84	South of Santa Helena, Mexico			Pence et al. (1986)
F15	01/1986	Born of F7	0		Davin (1987)
	02/28/87	Collared	1	45	
	04/13/87	Disassociated from F7	1.3		Davin (1989)
	04/24/87	Recollared	1.3	45	Davin (1987)
	06/29/87	Renamed FL3			Davin (1987)
	08/1987	Dispersed to Christmas Mts.	1.6		Ruth (1991)
	09/10/87	Last location in Christmas Mts	1.7		Davin (1989)
F16	01/1986	Born of F7	0		Davin (1987)
	03/01/87	Collared	1		
	06/02/87	Observed to be underweight Observed by visitors	1.5		Davin (1987)
	06/27/87	Renamed FL2			Davin (1987)
	11/1987	Disassociation from F7	1.9		
	03/13/88	Recollared	2.1	59	McBride and Ruth (1988)
	07/1988	Dispersed	2.5		Davin (1989)
	12/07/88	Near Santiago Peak			Davin (1989)
	02/1989	Trapped, killed near Santiago	3		Ruth (1991)
F17	01/12/88	Collared at Ward Springs	3	70	McBride and Ruth (1988)
	03/16/88	Associated with M14			Davin (1989)
	01/04/90	Died, puncture wound on head Smokey Spring	5		Ruth (1991)
F20	04/1989	Born of F07	0		Ruth (1991)
	03/16/90	Collared in Basin campground	0.9	43	Ruth (1991)
	05/31/90	Dispersed to Terlingua Ranch	1.1		Ruth (1991)
	07/21/90	Died at Nine Point Mesa	1.3		Ruth (1991)
F22	12/1988	Born of F05	0		Ruth (1991)
	03/26/90	Collared in Basin Disassociated from F05	1.2	35	Ruth (1991)
	04/19/90	Fed on carcass of F05 Sighted in Basin repeatedly			Ruth (1991)
	07/1990	Dispersed to south of Chisos	1.5		Ruth (1991)
	08/07/90	Recollared near Ward Spring	1.6	34	Ruth (1991)

[a] Age was estimated from pelage characteristics and tooth wear or replacement (Ruth 1991) and is generally within a 1-3 yr range of error.

Table 6. Chronological record of resident female mountain lions monitored at Big Bend National Park

Identity	Date	Occurrence	Age[a] (yrs)	Weight (lb)	Reference
F4	01/10/84	Collared near Grapevine Hills	7	55	Pence et al. (1986)
	10/26/84	Birth of 2 male kits	7		Pence et al. (1986)
	02/04/85	Trapped, died in Rosillas Mts.	8		Davin (1989)
F5	01/11/84	Collared in Blue Creek Canyon	3	65	Pence et al. (1986)
	11/1985	Recollared	4		Davin (1987)
	02/22/87	Associated with M14 for 3 d	6		Davin (1989)
	06/29/87	Renamed FL5			Davin (1987)
	07/14/87	Associated with M14 for 2 d			Davin (1989)
	09/1987	Birth of 2 kits, unsexed	6		Ruth (pers. obs.)
	10/30/87	Kits were unhealthy			Davin (1989)
	12/12/87	Recollared	6	63	McBride and Ruth (1988)
	06/22/88	Asociated with M14 for 3 d	7		Davin (1989)
	09/27/88	Associated with M14 for 1 d	7		Davin (1989)
	12/17/88	Localized at den site	7		Davin (1989)
		Birth of 2 kits, M21, F22			Ruth (1991)
	11/08/89	Recollared	8	68	Ruth (1991)
	04/19/90	Died near Basin amphitheater	9	35	Ruth (1991)
F6	01/31/84	Collared in McKinney Hills	5	70	Pence et al. (1986)
		Dart hit bone of right foreleg			
	02/1984	Died in Dead Horse Mountains			Pence et al. (1986)
F7	12/1983	Birth of male kit (M10)			Pence et al. (1986)
	02/09/84	Collared in Green Gulch	6	72	Pence et al. (1986)
	10/1985	Recollared	7		Davin (1987)
	01/1986	Birth of M12,F15,F16	8		Ruth (1991)
	06/29/87	Renamed FL1			Davin (1987)
	10/22/87	Recollared	9	83	McBride and Ruth (1988)
	01/17/88	Attended by M14 for 5days			Davin (1989)
	06/16/88	Attended by M14 for 2 days			Davin (1989)
	02/17/89	Attended by M14, Rock Spr.	10		Ruth (1991)
	04/1989	Birth of 2 kits (1 male, F20)	10		Ruth (1991)
	11/16/89	Recollared	10	75	Ruth (1991)
F8	02/11/84	Collared near Ash Spring	9	68	Pence et al. (1986)
	11/1984	Immobile near Pummel Peak			Pence et al. (1986)
	02/1985	Observed lame in hindlegs	10		Pence et al. (1986)
	03/1985	Dispersed to Rosillas Mts.			Pence et al. (1986)
	04/15/85	Natural death in Rosillas Mts.	10		Pence et al. (1986)
F11	02/1985	Collared near Paint Gap Hills	5	70	Pence et al. (1986)
	02/24/85	Moved into range of F04			Davin (1989)
	08/1986	Birth of 2 kits (M18)	6		Ruth (1991)
	01/22/87	Recollared	6		Davin (1987)
	06/29/87	Renamed FL4			Davin (1987)
	02/21/88	Recollared	8	84	Ruth (1991)
	10/1988	Trapped, killed outside park	8		Ruth (1991)

The total area of use was plotted for each mountain lion by displaying all locations recorded from 1983-1990 and drawing a convex polygon from the outermost points. Since the habitat is not homogeneous geographically, we did not consider it appropriate to use statistical approaches to analyzing home range. The purpose of this treatment of the data was to identify which mountain lions used the area of high recreational development in the Chisos Basin.

Tracks from 3-day focal animal samples were displayed by connecting sequential locations taken at 15-min. intervals. These data were used to determine (a) whether the focal animal was more likely to be in high recreational development areas during the day or night, and (b) seasonal changes in use of the recreational development areas defined for the CMMZ.

Only those tracks that crossed the areas of high recreational development were used for analysis of day (0800 to 1945) vs. night movements (Ruth 1991). Each location was tallied in a crosstabulation table of day/night vs. recreational development area (RDA1-B, RDA2, RDA3, RDA4). Data were analyzed using Chi-square (Conover 1980) and Freeman Tukey Deviates (z scores)(Bishop, et al. 1976). Analyses were performed separately for the adult female (F05) and the subadult female (F22).

All tracks sampled from F05 were used for seasonal analysis of movements (Ruth 1991). The seasons were defined as spring (April - June), summer (July - September), fall (October - December), and winter (January - March). Samples were obtained for all but the months of April and November from March 1989 through March 1990. The number of locations in each recreational development area were counted for each sample and analyzed using the non-parametric Friedman's 2-way analysis of variance (Conover 1980). Tracks of the adult female (F05) were plotted on one map for each season. Tracks of the subadult female were plotted on one map (April - July) and monthly changes were analyzed using Friedman's test (Ruth 1991).

Seasonal changes in distribution of the two adult females that used the Basin (F05, F07) were analyzed using the GRASS geographical information system. Locations during each year (1984-1990) were plotted on a separate map for each season and each individual. The sampling area was a 10 km by 11 km frame including the recreational development areas defined as RDA1-B, RDA2 and RDA3 (Figure 2). Locations were tallied by individual, year, season and recreational development area. Since the sampling effort varied between years and areas differed in size, no statistical analyses were performed. Also, all locations of the adult females (F05, F07) and their offspring (F20, M21, F22) within this window were plotted on one map to show details of distribution relative to trails, drainages and roads in the Chisos Basin.

Three confounding variables should be considered in interpretation of analyses. First, during the daily sampling schedule, locations were usually determined during daylight hours. A plan to distribute daily samples evenly throughout four time-blocks was not logistically feasible. If there was a diurnal change in distribution, the locations obtained from ground and aerial telemetry would therefore be biased. This is why a 3-day continuous monitoring schedule was developed for focal animal samples. Second, ground searches were biased to overrepresented areas accessible by roads and trails. Third, radio contact was sometimes lost during 3-day samples, resulting in some periods of extrapolation or missing data.

Results

Overlap of Home Ranges with the Chisos Basin

Two of the three adult male lions that were monitored have used the Chisos Basin without negative incident (Figure 3). M14 was located primarily in areas peripheral to the Basin during 1989-1990 (Ruth 1991), but he previously was located more often in the Basin. This male was probably the father of litters born to adults females F05 and F07 since he was located in close proximity to them during periods corresponding to estrus two months prior to birth

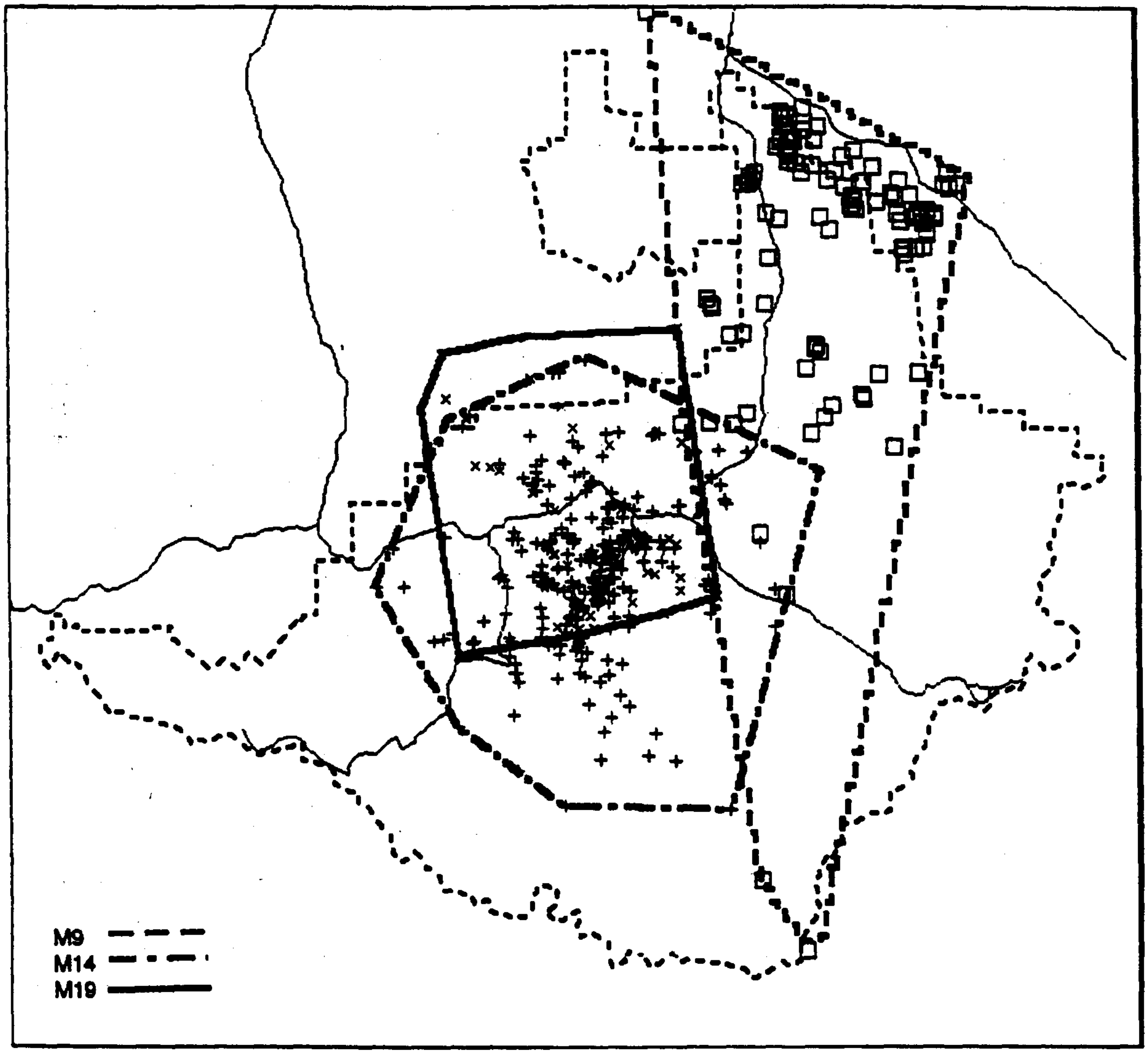

Figure 3. Home ranges of adult male mountain lions. Symbols denote the locations of M9 (squares), M14 (+) and M19 (x). Thin dashed lines are park boundaries and thin solid lines are roads. The scale is 1 inch to 16 kilometers.

of the litters. The second male (M19) was trapped in Green Gulch along the road entering the Basin, but was subsequently located primarily north of the Basin.

None of five adult females caused negative interactions with humans (Table 6). Two adult females (F05, F07) have consistently used the Chisos Basin over six years (Figure 4). Their ranges overlap in the foothills north of the Basin, the Basin, Juniper and Pine Canyons and the Boulder Meadows regions. However, much of the overlap was in the initial years of the study (Waid 1990). In the present study, F05 was located more often in the Basin and F07 was located in the Panther Peak area (Ruth 1991). An older female (F08) occupied the foothills northeast of Panther Peak prior to dispersal and death outside the park in the Rosillos Mountains (Waid 1990). A female (F04) that was caught in Grapevine Hills, ranged as far north as the Harte Ranch and was killed in the Rosillos Mountains (Waid 1990). Her range was taken over by another adult female (F11) who was also killed outside the park (Waid 1990).

The home ranges of the two females (F04, F11) that occupied the Grapevine Hills area were larger than the home ranges of the Basin (F05) and Panther Peak (F07) females (Waid 1990). The Grapevine females occupied more area of Shrub Desert vegetation than the Basin and Panther Peak females. The Panther Junction residential development was included in the home ranges of the Grapevine females.

Three of six young males (less than four years) have caused adverse interactions with humans (Table 4). Two young males (M01, M10) died outside the park without causing incidents. One of these (M10) occupied an area that included the Basin (Figure 5). A young male (M14) estimated to be 3 years old at capture (Table 4), has been located consistently in the periphery of the Basin as an adult (Figure 3).

A son (M12) of the Panther Peak female (F07) attacked a woman on the Basin Loop trail in April 1987, the same month that he stopped associating with his mother (Table 4). He was 15 months old at the time and was killed by park personnel. His range included Panther Peak, the Basin and South Rim (Figure 5).

A son (M18) of the second Grapevine female (F11) was captured and relocated to a captive breeding program because he showed no fear of humans in the area of Government Springs (McBride and Ruth 1988; Ruth 1991). This occurred in May 1988, two months after he stopped associating with his mother, when he was 21 months old (Table 4). This male occupied a range similar to his mother (Figure 5).

A son (M21) of the Basin female (F05) attacked a dog in the Basin campground and was relocated within the park (Ruth 1991). This occurred in June 1990, three months after he stopped associating with his mother, when he was 18 months old (Table 4). He was probably involved in two negative incidents reported by hikers (at Boulder Meadows and the Basin Loop trail) and an approach reported by a research assistant (on La Paloma ridge; Table 2, Ruth 1991). Prior to relocation, this male occupied an area similar to his mother (Figure 5). After relocation to McKinney Springs, he followed a drainage to the Rosillos mountains and died in that area (Ruth 1991).

None of seven young females caused adverse interactions with humans in the park (Table 5). Five dispersed from the park, four to the north (F2, F15, F16, F20) and one to the south (F3; Figure 6). Of the four that dispersed to the north, three died on ranches (Table 5).

A young female (F17) that was captured near the Rim, subsequently occupied the Desert Shrub region southwest of the Basin (Figure 6). Although she associated with the Periphery male (M14) reproduction was not confirmed (Table 5). She was found dead near Smokey Spring, with puncture wounds on the head (Ruth 1991).

A daughter (F22) of the Basin female (F05) dispersed from the Basin without negative incident, although she showed little fear of humans (Tables 2, 5). Her range shifted from the Basin to the Desert Shrub region south of the Basin (Figure 6). Her movements were studied in more detail during 3-day tracking after her mother died.

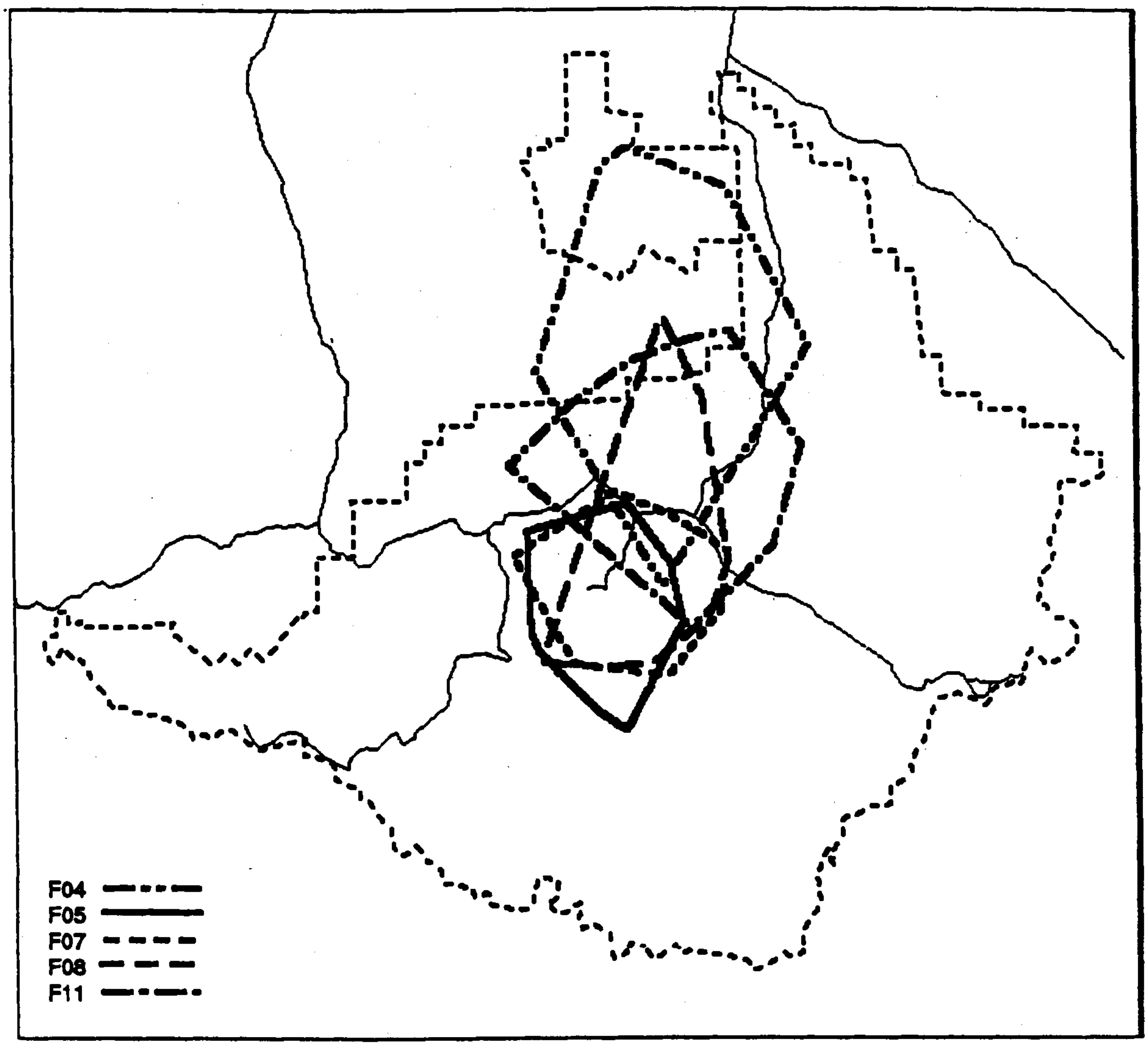

Figure 4. Home ranges of reproductive female mountain lions. Polygons denote the home ranges of F04 (dash-double-dot line), F05 (solid line), F07 (short dashed line), F08 (long dashed line) and F11 (dot-dashed line). Thin dashed lines are park boundaries and thin solid lines are roads. The scale is 1 inch to 16 kilometers.

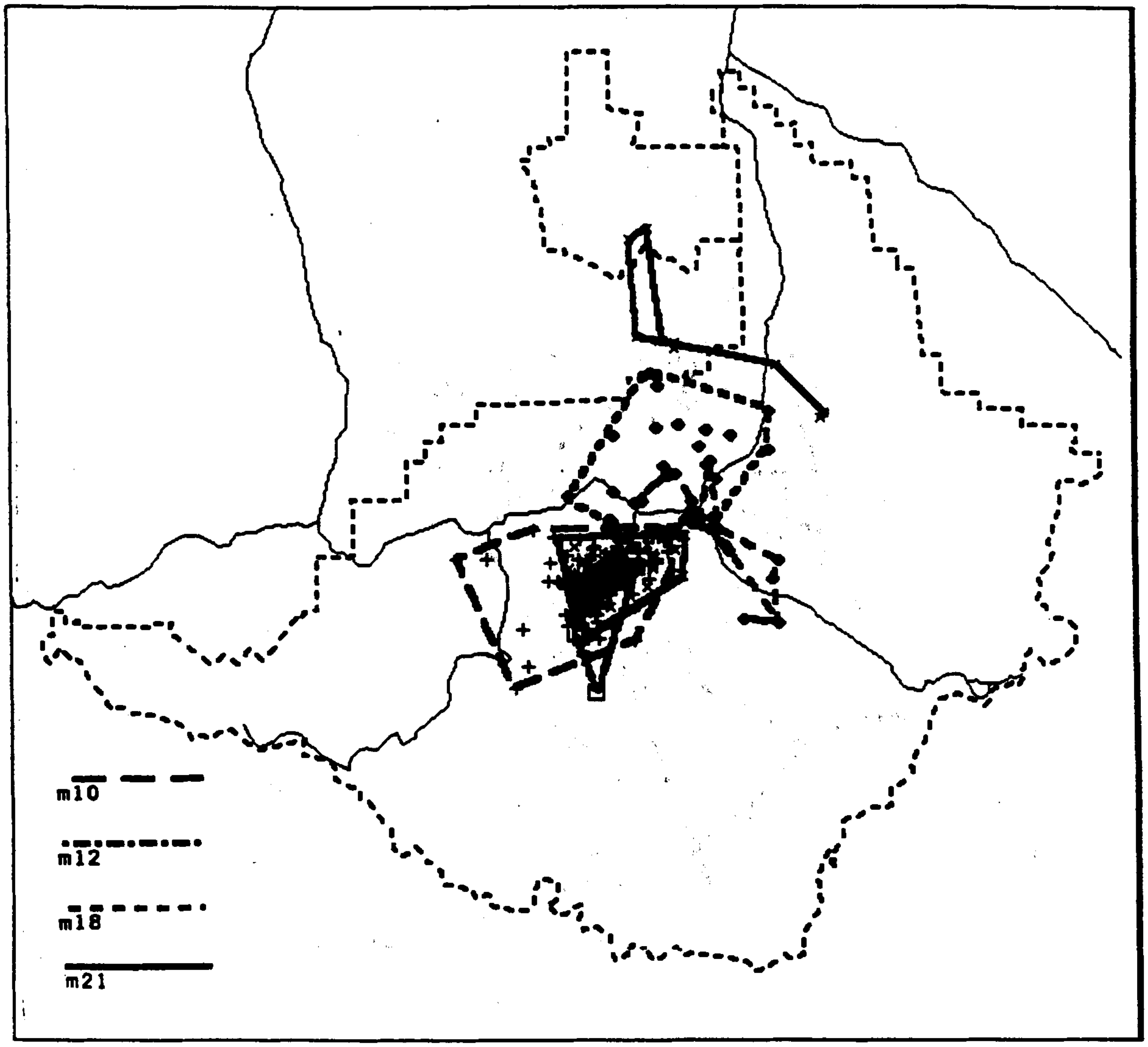

Figure 5. Home ranges and dispersal tracks of young male mountain lions. Symbols denote the locations of M10 (+ and long dashed line), M12 (□ and dot-dash line), M18 (• and short dashed line), and M21 (x and solid line). Thin dashed lines are park boundaries and thin solid lines are roads. The scale is 1 inch to 16 kilometers.

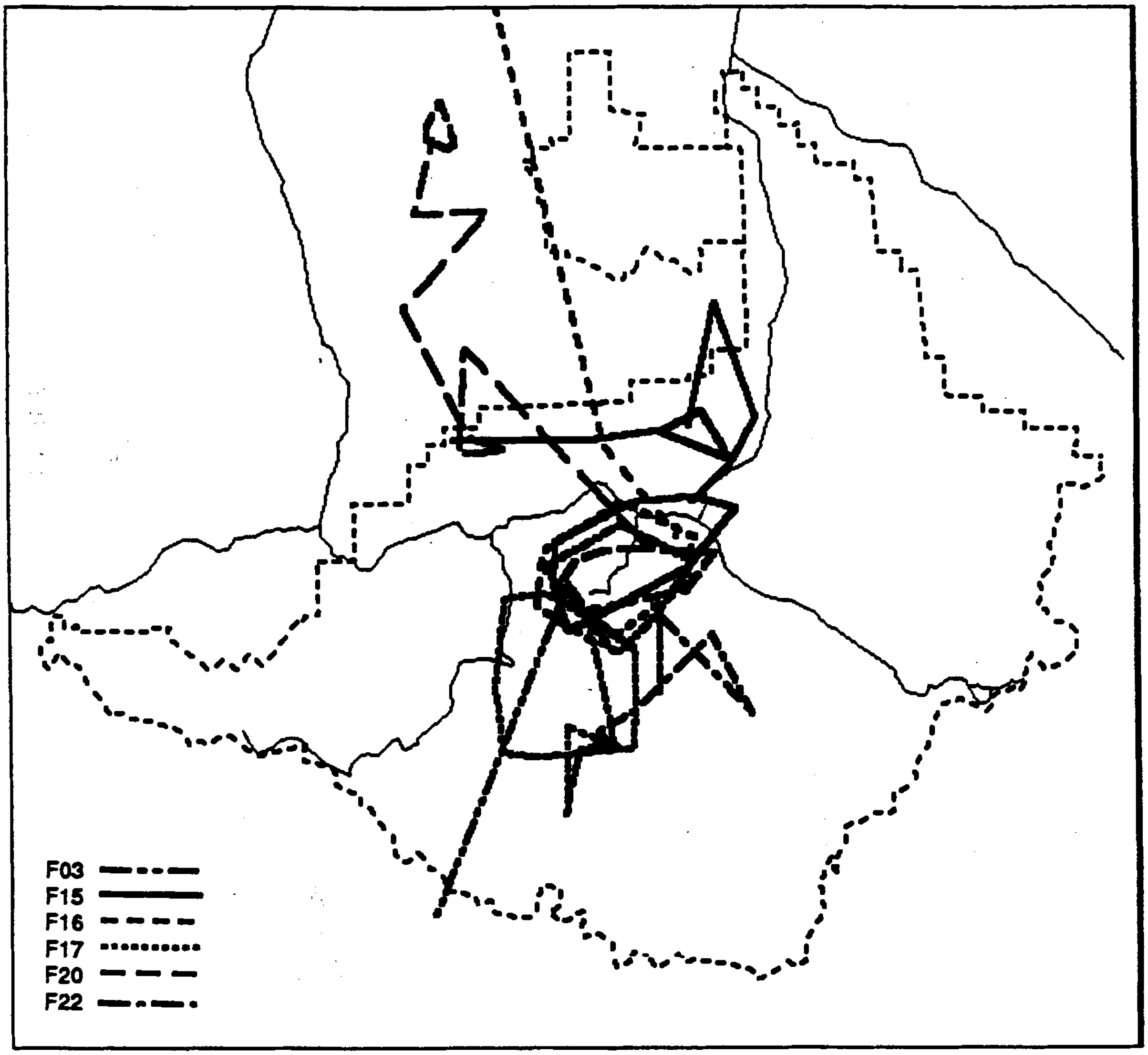

Figure 6. Home ranges and dispersal tracks of young female mountain lions. Polygons denote the home range and dispersal tracks of F03 (dash-double-dot line), F15 (solid line), F16 (short-dashed line), F17 (dotted line), F20 (long- dashed line), and F22 (dot-dash line). Thin dashed lines are park boundaries and thin solid lines are roads. The scale is 1 inch to 16 kilometers.

Movements during Monthly 3-day Samples

The extent of the Basin female's movements varied considerably during 3-day samples (Ruth 1991). For example, in March (1989) she moved from Lower Juniper Springs to the cliff west of the South Rim trail, then crisscrossed the slopes southwest and northeast of the Juniper Canyon trail (Figure 7). In May, she moved along the slopes and drainage north of the Basin campground, then crossed between the campground and lodge to Casa Grande. In June, she was stationary on a deer kill. During this period, her litter was 3-6 months old, presumably just beginning to follow her.

During the extremely dry summer of 1989, the Basin female's movements were more restricted during July and September (Figure 8). In August, she moved from Emory Peak to Ward Mountain, then crossed the area of the Basin Loop trail to Casa Grande, dipped down into the drainage west of the Basin campground and back up to Lost Mine Peak. During September, she acted as if she was on a kill near the Boot Springs trail, but no sign was confirmed. Her 7-9 month old litter would have been fairly mobile at this time.

Movements during the unusually dry fall of 1989 were again extensive (Figure 9). During October, the Basin female moved from Juniper Canyon through the Boot Springs area, and dropped off the South Rim to Lower Juniper Springs. In December, she moved along Pine Canyon then over to Lost Mine Peak. Her litter was 10-11 months old, a time when they have nutritional requirements similar to adults.

During spring of 1990, the Basin female moved within the Basin (Figure 10). In January, she crossed rapidly during the night from Pine Canyon to Ward Peak, then to the slopes of Vernon Bailey north of the Basin campground. Twice, she looped into Green Gulch, up to Lost Mine Peak, then past the developed area in the Basin to the Vernon Bailey slopes. She was near Casa Grande at the end of the sample. In February, she moved along the slopes north of the campground, crossed over to the northern slopes of Pulliam Bluff, then returned through Green Gulch to Casa Grande. In March, she crossed from the slopes north of the campground, between the campground and lodge, through the Basin Loop area, then circled around south and west of Emory Peak and Ward Mountain. Her movements were near the Boulder and Laguna Meadows backcountry campsites. This was the season when her litter was in the process of disassociation and several incidents were reported (Table 2).

Locations of the Basin female relative to recreational development areas varied significantly across seasons ($P < 0.001$; Ruth 1991). She was located more often in areas of high recreational development during fall and winter than during spring and summer (Figure 11). She was extremely underweight at the time of her death near the Basin amphitheater (Table 6).

During the 3-day samples when tracks of the Basin female crossed high recreational development areas in the Basin (Figure 12a), her locations relative to the development was significantly different between night and day ($X^2 = 73$, 3 df, $P < 0.00$; Ruth 1991). She was located significantly more frequently near the campground and lodge (RDA1-B) at night ($z = 4.9$) than during the day ($z = -9.6$).

In contrast, the Basin female's subadult daughter (F22) did not avoid the area of the campground and lodge (RDA1-B) during the day (Figure 12b). Her locations relative to the recreational development areas differed significantly between night and day ($X^2 = 33.5$, 3 df, $P < 0.00$; Ruth 1991). She was located more frequently near the campground and lodge during the day than the night, although this difference was not significant ($-1.96 < z < 1.96$). She fed from the carcass of her mother near the Basin amphitheater during the April sample and was extremely underweight for her age (Ruth 1991).

Over the four months following her mother's death, the tracks of the Basin subadult female were located further from the Basin (Figure 13; Ruth 1991). In April, she was exclusively within the Basin. In May, she moved rapidly from Pine Canyon (where she walked through the monitoring camp without incident)

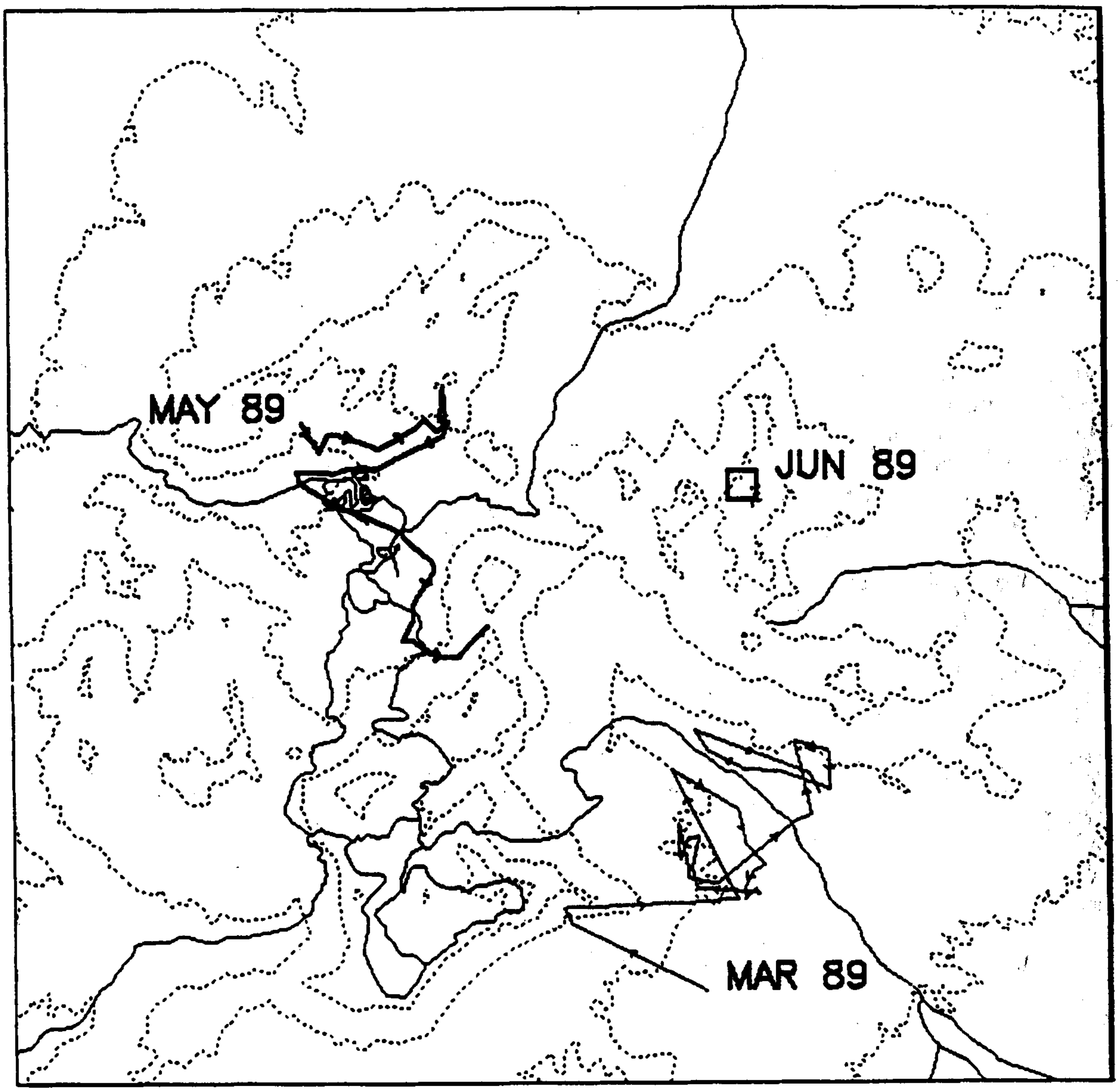

Figure 7. Spring movements of adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

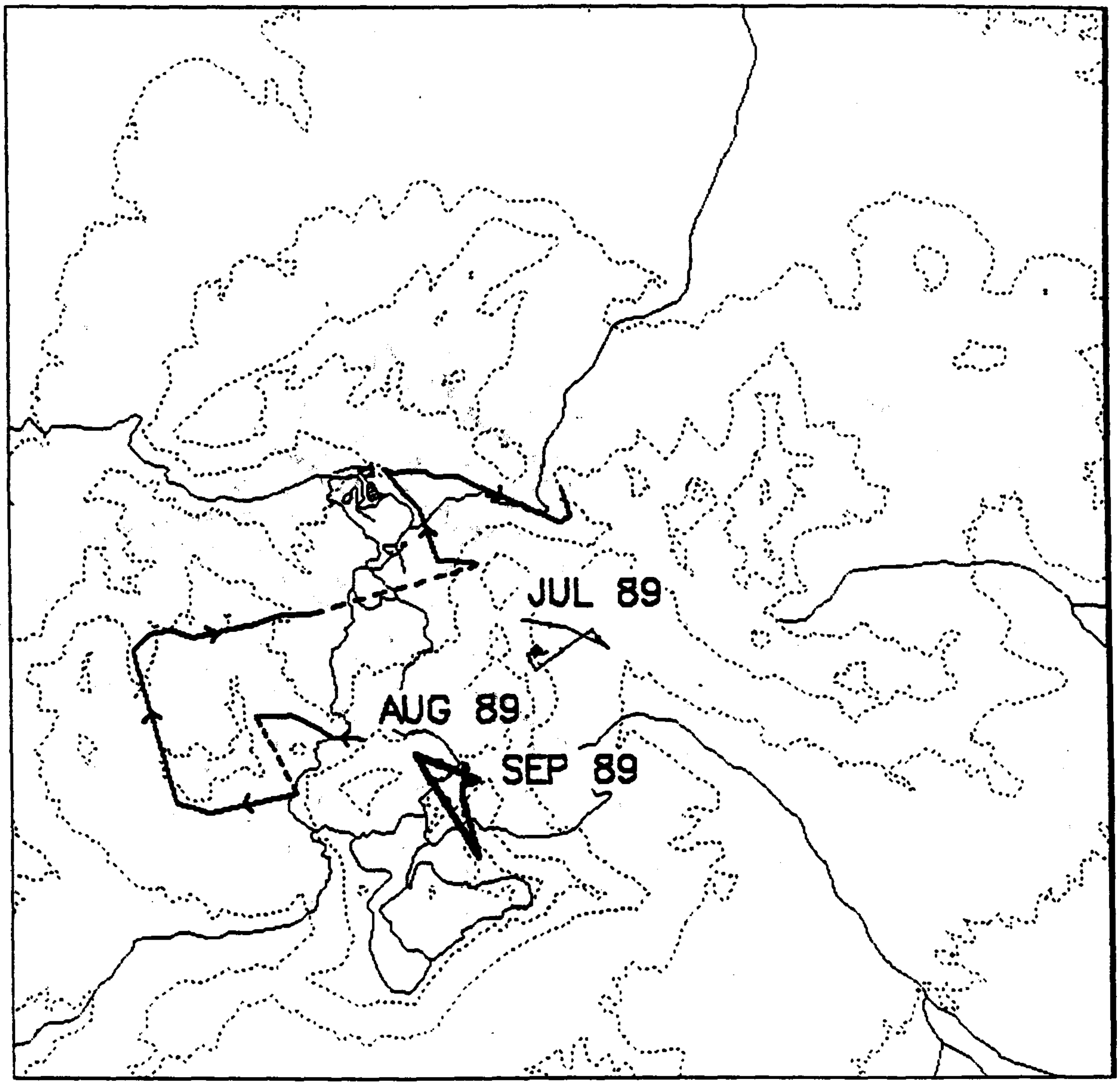

Figure 8. Summer movements of adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

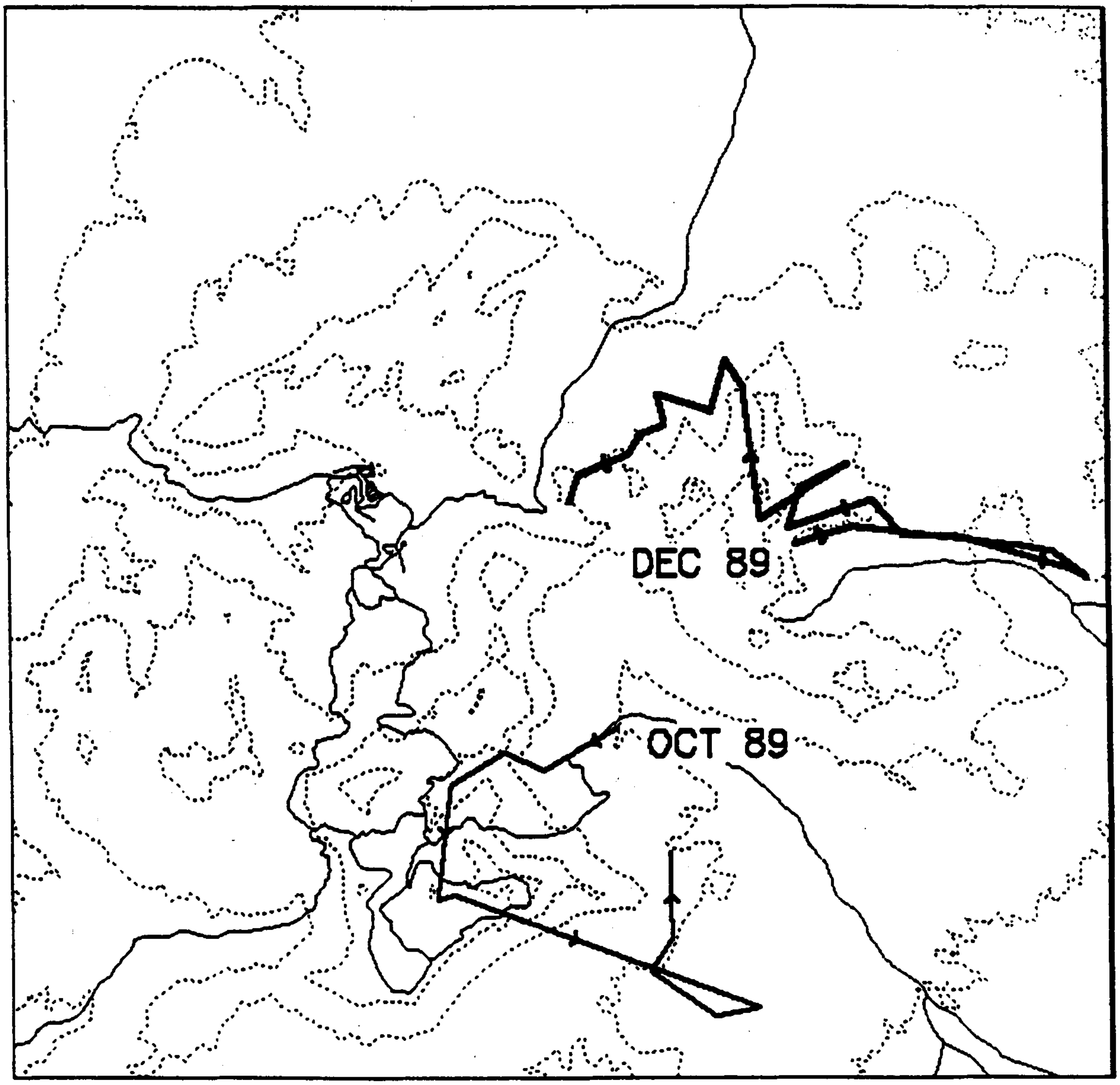

Figure 9. Fall movements of adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

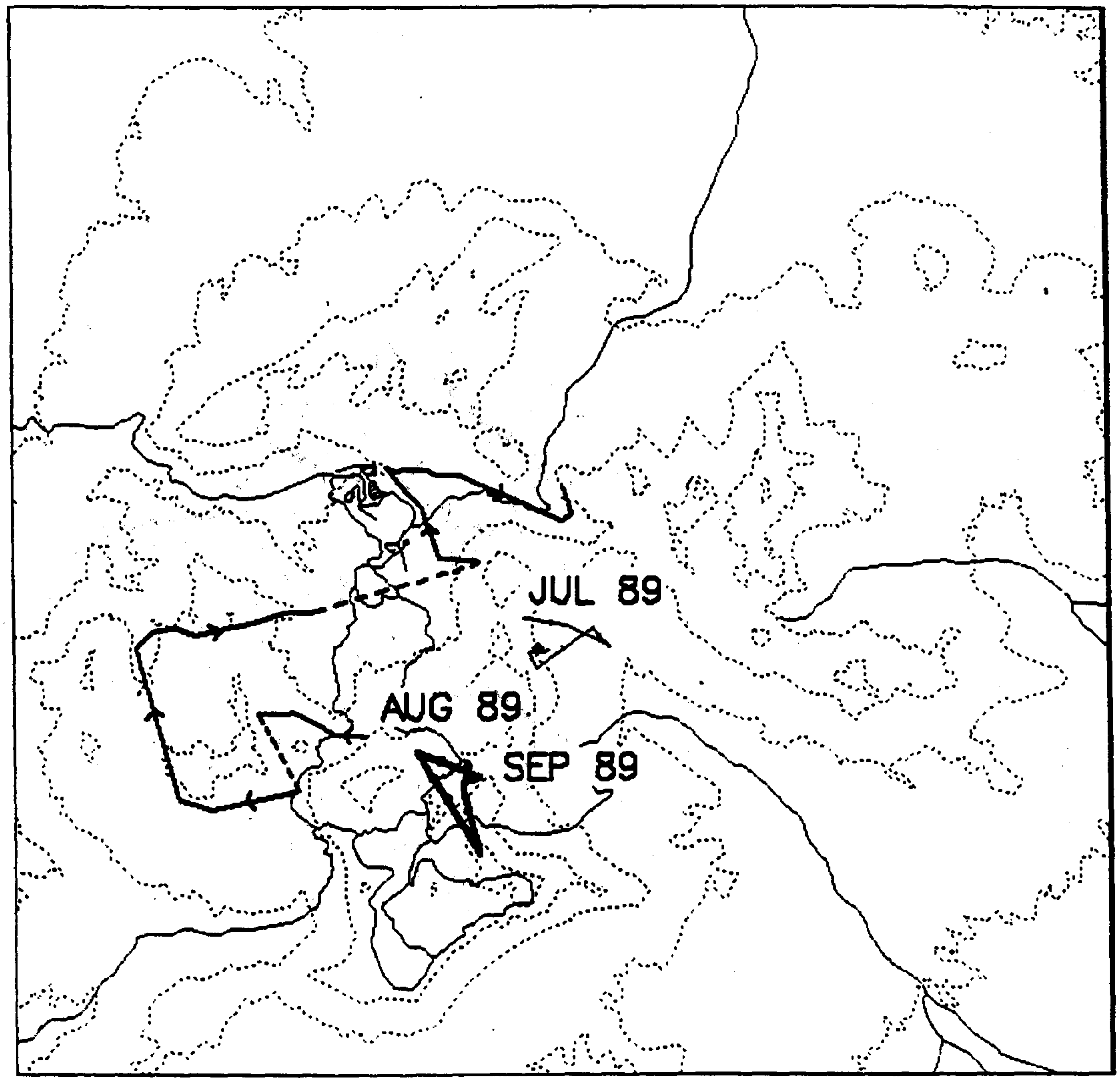

Figure 8. Summer movements of adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

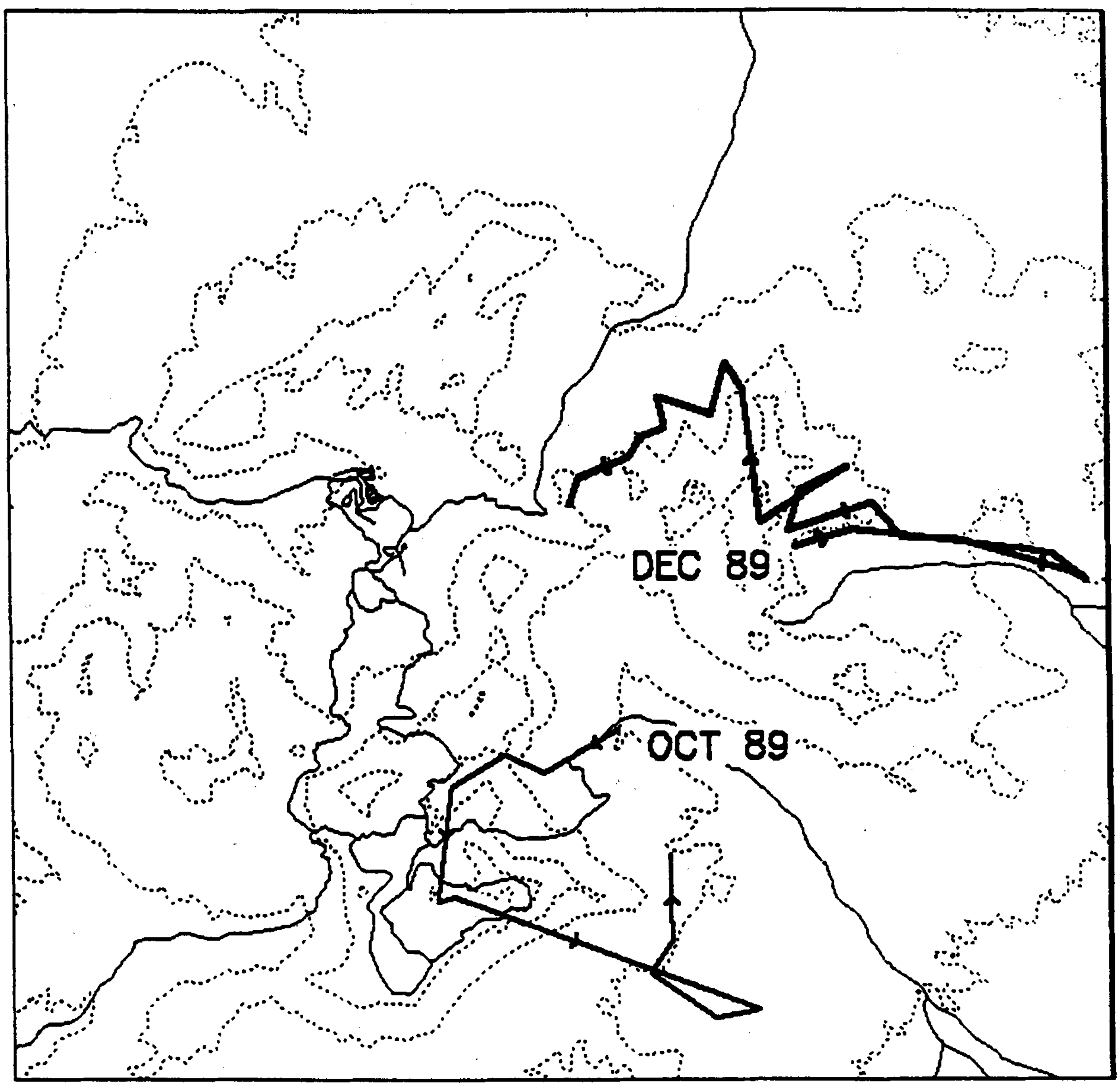

Figure 9. Fall movements of adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

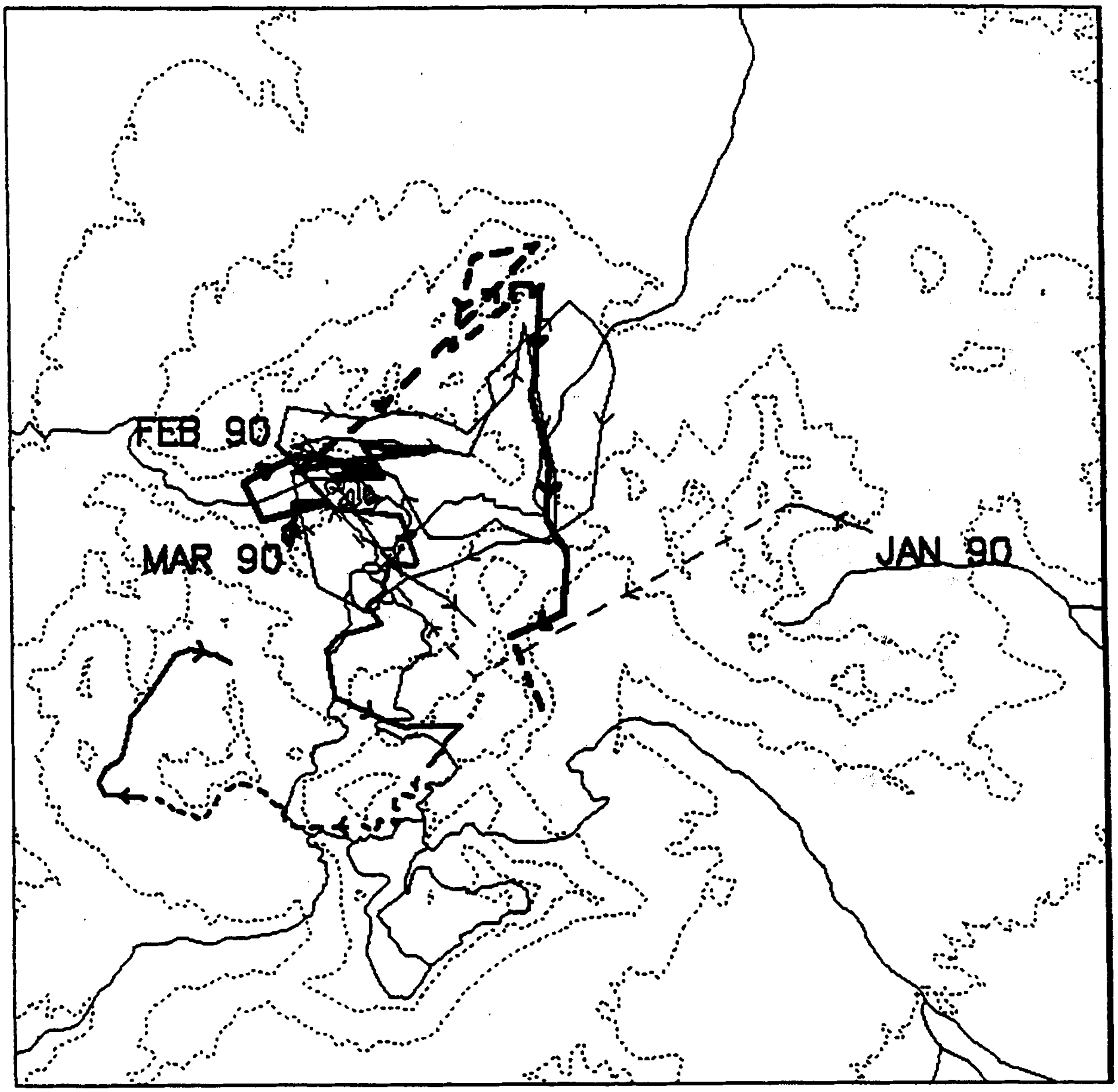

Figure 10. Winter movements of the Basin adult female (F05) during 3-day samples. The thin solid lines are roads and trails and the dotted lines are contours. The arrows on the tracks indicate the direction of movement. Dashed portions of tracks indicate periods when radio contact was intermittent. The scale is 1 inch to 2 kilometers.

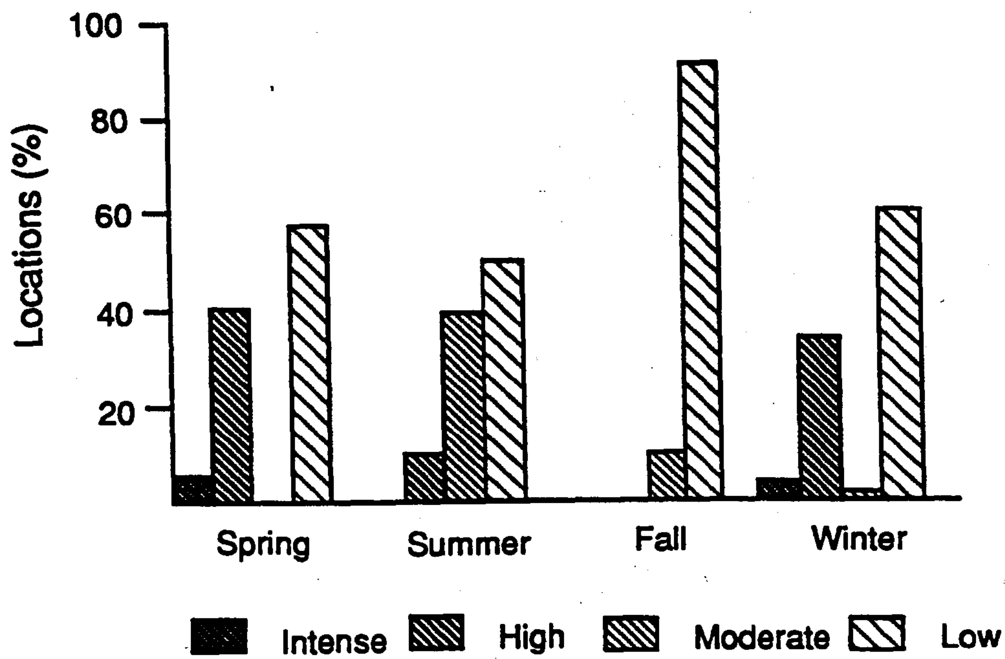

Figure 11. Seasonal changes in use of recreational development areas by the Basin adult female (F05) based on monthly 3-day samples (from Ruth 1991).

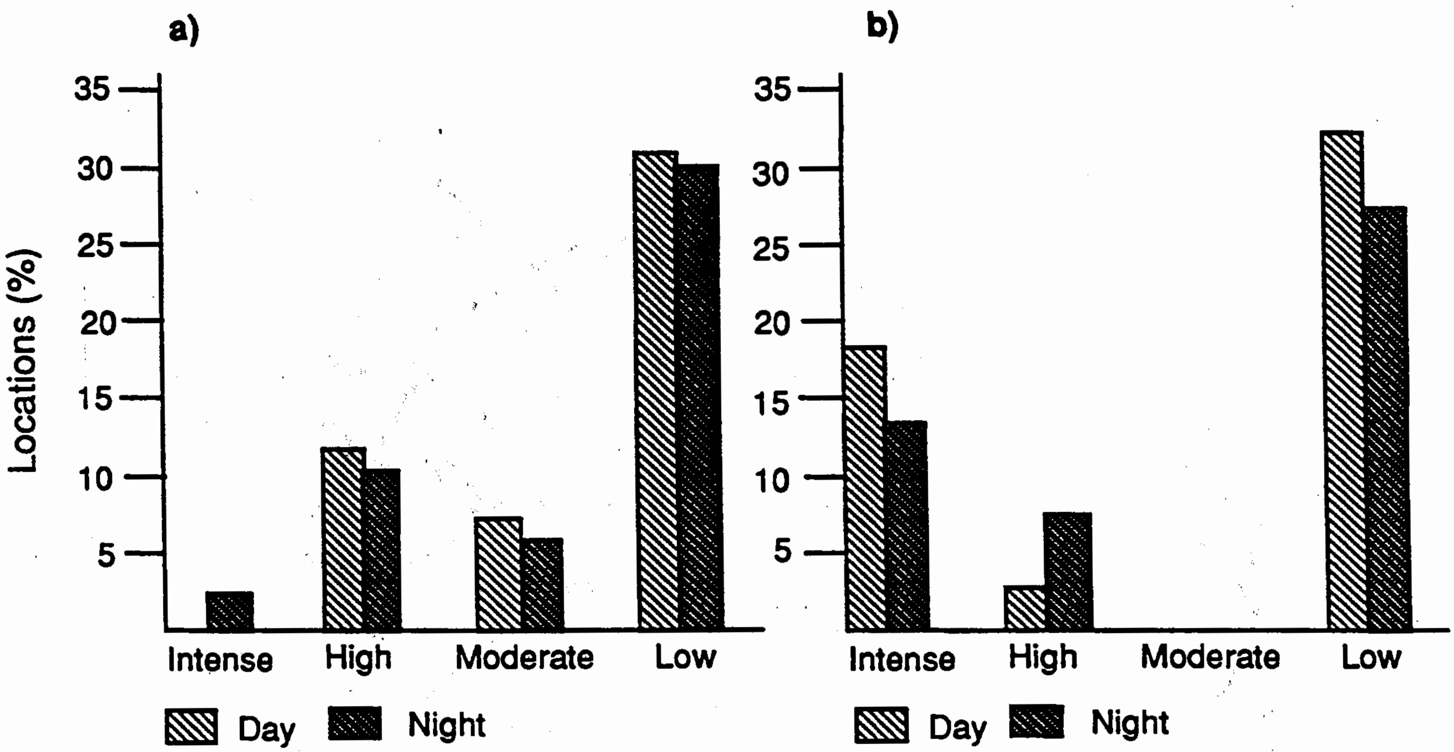

Figure12. Day vs. night locations in each Recreational Development Area based on monthly 3-day samples of (a) the Basin female (F05) and (b) her daughter (F22).

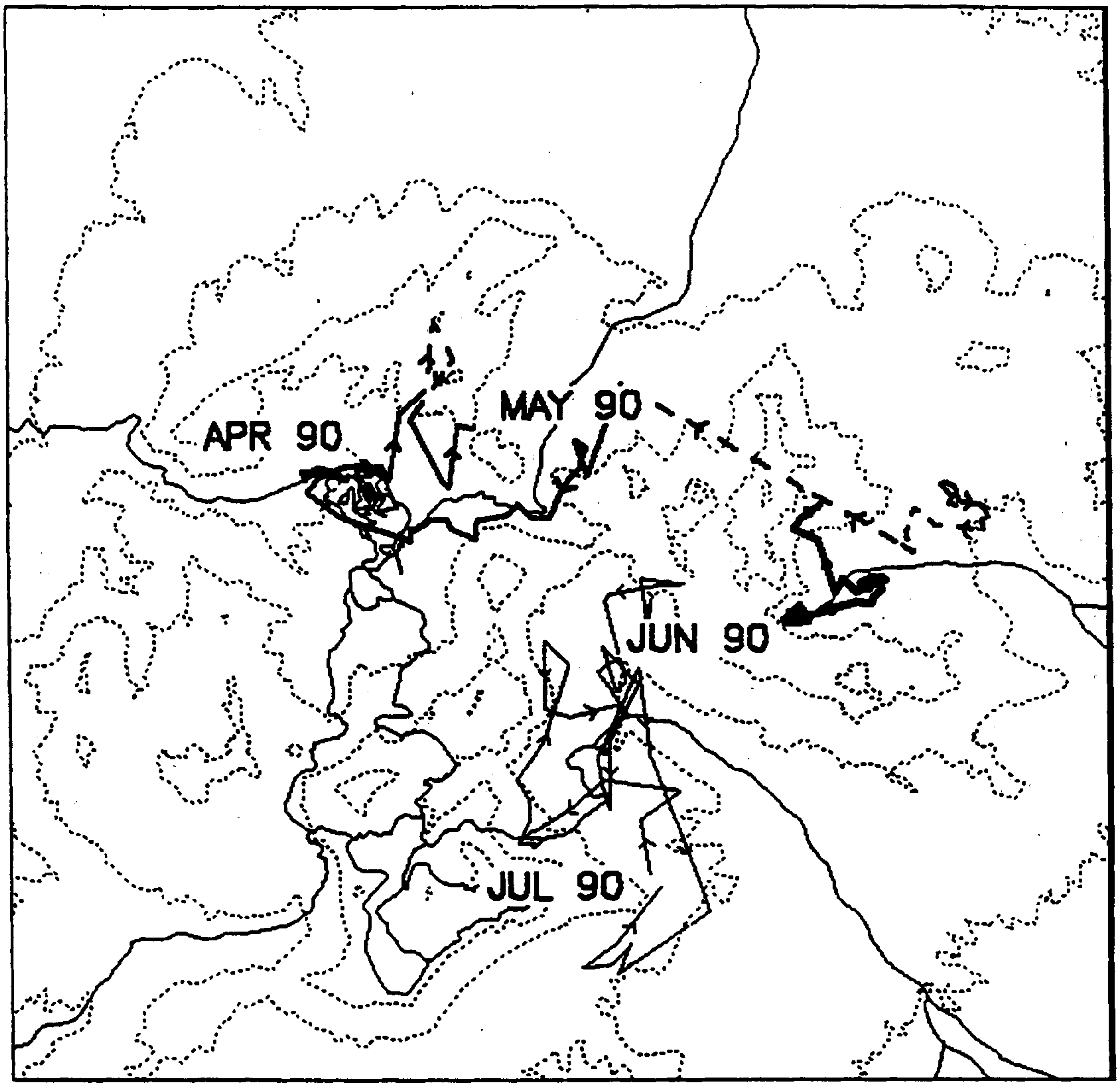

Figure 13. Movements of subadult female (F22) during 3-day samples for each of four months after the death of her mother (F05).

to the drainage north of the campground, then north to Pulliam Reach. She followed a route similar to that used by her mother in the winter. In June, she was again in Pine Canyon and moved through the monitoring camp without incident (Table 2). In July, she moved extensively along the slopes of Juniper Canyon and crossed the trail several times. At the time of recollaring in August, she had not lost weight, but was still half the expected weight for her age (Table 5).

Locations in the Highly Developed Recreational Area

In the Basin, mountain lion locations clustered near drainages north and west of the campground, the Basin Loop trail, the pass between Lost Mine Peak and Casa Grande, the slopes of Casa Grande and Toll mountains, Green Gulch, the pass northeast of the Basin at Telephone Gap, and a drainage near the Juniper Canyon trail (Figure 14). Several of these locations correspond to locations where mountain lion approaches were reported (Tables 1 and 2).

The seasonal changes in distribution of the Basin female (F05) during 1989-1990 were not typical of other years (Figure 15). In general, the Panther Peak female (F07) was less likely to be in the Basin during summer and more likely during winter (Figure 16). However, such patterns varied by year.

Movement of the Panther Peak female into the Basin occurred during winters when her litters were near adult size, but not when she had small kittens. During 1984-1986, the Basin female was not located more frequently in the Basin in winter and spring than during other seasons (Table 7). However, movement into the Basin was typical during 1987, 1988 and 1990.

Discussion

High Risk Profile

The existing data support the working hypothesis that subadult male mountain lions are individuals most likely to be involved in adverse interactions with humans. Since the sample size is still small, it is difficult to prove such an hypothesis. However, not all subadult male mountain lions caused adverse incidents. One subadult female showed little fear of humans but did not cause problems prior to dispersal.

Many factors may contribute to this profile of high risk mountain lions (Ruth 1991). All subadults that were captured twice showed a loss in body weight or low body weight during the period of dissociation from the family group. The motivation for obtaining food may be very high. At the same time, young mountain lions are learning how to capture and kill prey. During this learning process, they may not have yet learned what are suitable prey objects.

Attractants

Factors attracting mountain lions include (a) children unattended by an adult, (b) a pet dog chained at night in the campground, and (c) native prey possibly attracted to refuse and green vegetation near campsites and residences. Children and dogs may provide similar stimuli as native prey. They are small and relatively vulnerable. Although no attacks on horses or mules have been reported recently, one incident (Table 1) suggests that even large prey may be attacked, particularly if made vulnerable by enclosure in a corral. A leash law in the park requires that pets be tied at all times. However, if left unattended, particularly at night, such pets may be very vulnerable. In general, any factors that attract prey of mountain lions to campgrounds and residences may also attract mountain lions. The runoff from roads and watered gardens may create green vegetation attractive to herbivores. Pet food or garbage left near residences and campgrounds may attract omnivorous that are also prey for mountain lions.

Since mountain lions hunt by stalking rather than chasing prey, any factors contributing to concealment may increase the probability of encounter. For example, thick brush near trails or trails near drainages represent locations that place humans at risk to attack. Drainages and brushy areas near trails are typical places for a mountain lion to wait in ambush for native prey. Shrub understory has increased since the natural fire cycle has been suppressed in the Chisos Basin.

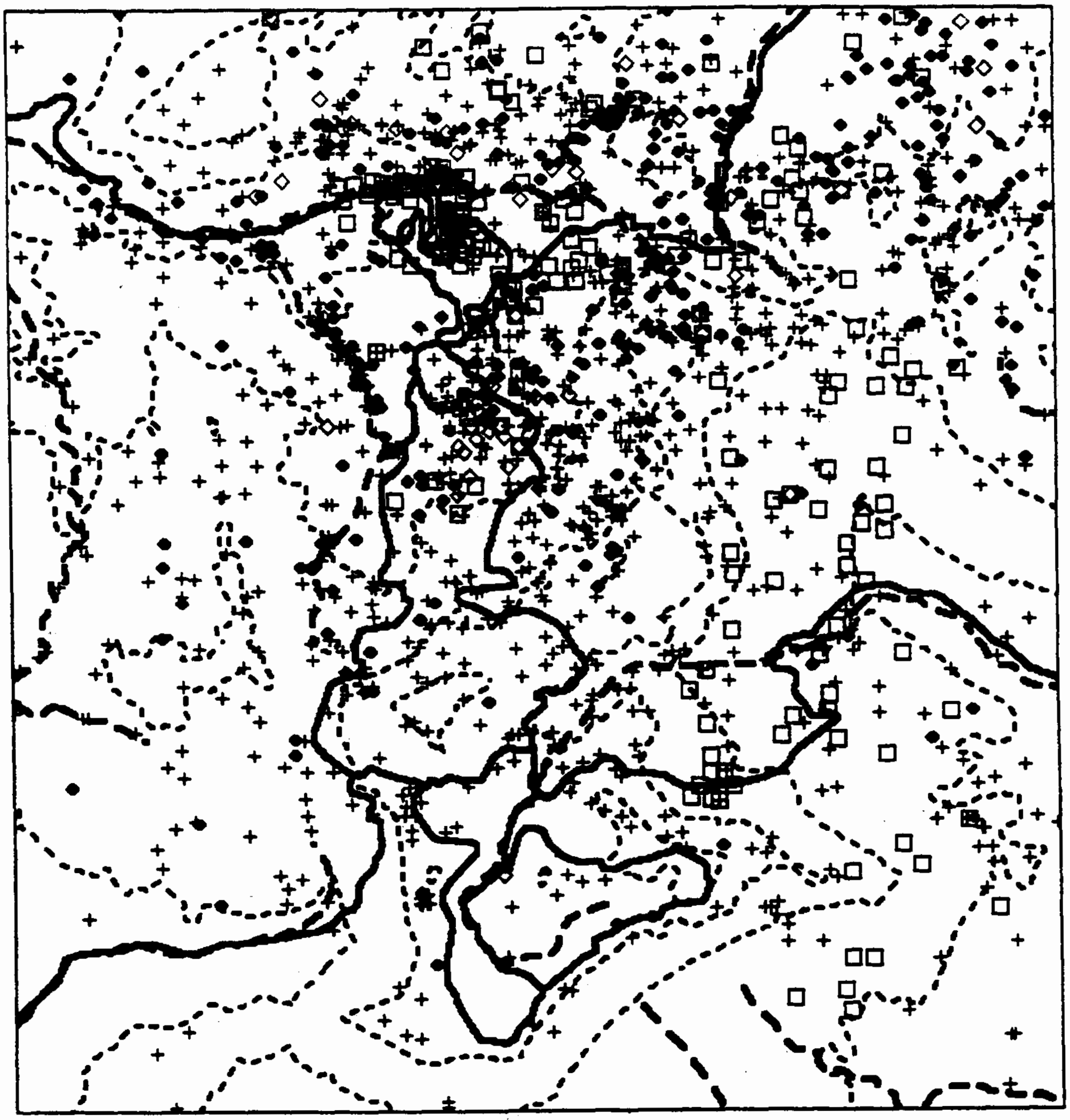

Figure 14. Mountain lion locations in the area of high recreational development. Thick solid lines are trails and roads. Thick dashed lines are drainages and thin dotted lines are contours. Symbols represent all locations recorded for F05 (+), F07 (•), F22 (squares), and M21 (diamonds).

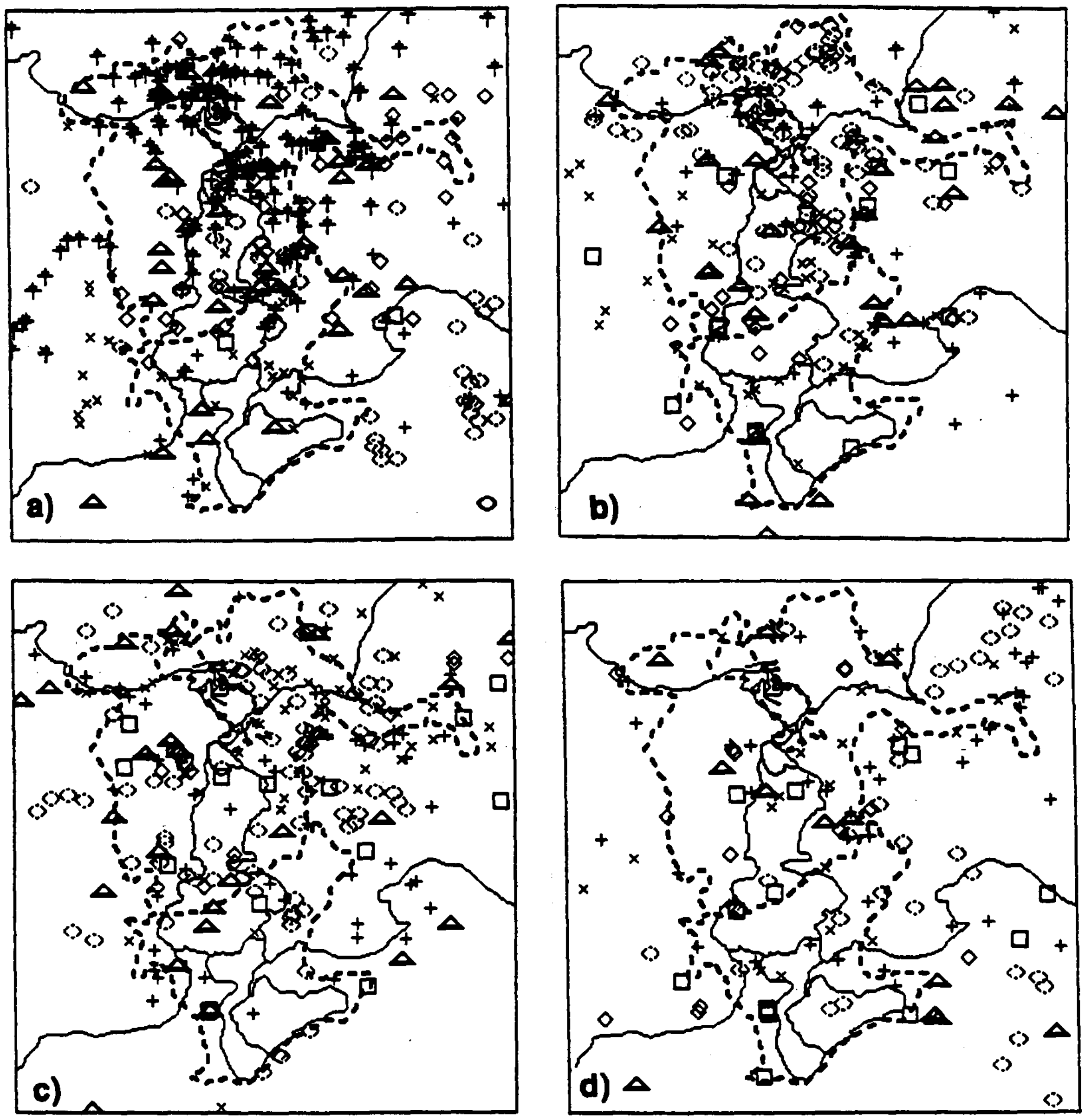

Figure 15. Seasonal use of highly developed recreational areas by the Basin female (F05) during each (a) winter, (b) spring, (c) summer, and (d) fall for six years (1984-1990). Symbols represent 1984 (+), 1985 (x), 1986 (square), 1987 (diamond), 1988 (triangle), 1989 (o), and 1990 (sword). The scale is 1 centimeter to 2 kilometers.

Table 7. Seasonal changes in location and reproductive status of two adult female mountain lions over six years (data compiled from Waid 1990, Davin 1987, McBride and Ruth 1988, Ruth 1991).

Season	Rain[a]	Basin Female (F05)					Panther Peak Female (F07)				
		Reproductive status[c]	Location[b] 1	2	3	4	Reproductive status[c]	Location[b] 1	2	3	4
1984											
winter	0		1	2	3	11	Y1	0	2	0	3
spring	2		1	8	3	9	Y2	1	6	0	8
summer	2		1	11	5	23	Y3	1	24	1	10
fall	2		0	8	5	23	Y4	2	11	3	10
1985											
winter	0		1	4	10	12	Y5	0	21	3	9
spring	2		0	13	11	10		1	14	0	0
summer	3		3	25	1	14		0	2	0	1
fall	0		0	8	4	3		0	0	0	5
1986											
winter	1		0	0	1	1	Y1	0	0	0	1
spring	1		0	3	4	7	Y2	0	1	0	2
summer	3		0	6	4	4	Y3	0	1	0	1
fall	2		0	4	4	5	Y4	0	6	0	7
1987											
winter	0	Estrus	0	14	4	11	Y5	0	19	1	7
spring	2		0	12	2	7		0	10	0	3
summer	3	Estrus, Y1	0	8	0	4		0	4	1	6
fall	0		0	7	0	7		0	1	0	5
1988											
winter	0		3	18	3	11	Estrus	0	3	0	6
spring	1	Estrus	0	10	4	15	Estrus	0	9	0	10
summer	3		0	8	4	11		0	2	0	6
fall	0	Estrus	0	6	0	5		0	0	0	2
1989											
winter	1	Y1	0	12	1	26	Estrus	2	3	1	16
spring	0	Y2	8	39	2	12	Y1	0	0	0	5
summer	1	Y3	0	31	10	29	Y2	0	3	0	11
fall	0	Y4	0	4	5	22	Y3	0	6	0	5
1990											
winter	0	Y5	17	69	7	32	Y4	0	16	0	5
spring	0	Dead	1	5	0	2	Y5	0	1	0	6
summer	3							0	1	0	0

[a] Number of months with above average rainfall (Ruth 1991).

[b] The numbers refer to areas of (1) intense, (2) high, (3) moderate, and (4) low recreational development (Figure 2).

[c] Estrus was determined by association of the female with a male. The codes correspond to age classes of litters, with Y1 indicating the first three months since birth and Y5 indicating over one year of age.

Two sets of factors may be separated in considering what stimulates a predator to attackattractive factors and releasing factors. Even after a mountain lion is attracted to the factors described above, the likelihood of an attack will depend on releasing factors. Stimuli that released attack included running away, crouching, and high pitched squeals in contrast to loud, low-pitched shouts. On two occasions, rangers have been contacted by a mountain lion that responded to their movements walking past (attractive factors) but did not continue the attack when the victim responded assertively (lack of releasing factors). Such experiences have led to recommendations that victims resist when attacked by mountain lions, in contrast to the advice to victims of bear attacks to play dead (Eagle Extra 1991). The rational is that the motivation for bear attacks is usually maternal defense in contrast to the mountain lion attack which appears to be prey-related.

Deterrents

Deterrents to attack included assertive behavior by adults who shouted, threw rocks, kicked at a mountain lion from lower branches of a tree, picked up a child and brandished an emergency flare (Ruth 1991). The flare was shoved in the face of the subadult male that attacked the dog only after other attempts to separate the two animals were not successful. In one case, a mountain lion that was crouched by the side of the trail left when a hiker came up the trail from the opposite direction.

Rock salt delivered from a shotgun was not effective at conditioning long-term avoidance (Ruth 1991). Aversive conditioning needs to be persistent and consistent to be effective. If a program of aversive conditioning were desired, it would be necessary to have a crew that stayed with a problem animal and applied the aversive stimuli every time undesirable behavior occurred.

Ruth (1991) examined the question of whether young mountain lions become habituated to the presence of humans if their mother's range includes areas of high development. During the nine months after their litters were born, both the Basin female and the Panther Peak females seemed to avoid the areas of high recreational development. Habituation would not have occurred at this time. Kittens were so secretive that they even avoided researchers searching for them. If habituation occurs, it would appear more likely during the subadult stage.

Recommendations

Alternative actions suitable for inclusion in a management plan for mountain lions in BBNP have been identified and evaluated by Ruth (1991). A proactive rather than reactive policy was recommended. This would involve (1) trail improvements to reduce risk near drainages, ridges and thick vegetation, (2) education regarding protection of children and pets, (3) reduction of attractants for prey near campsites and residences and (4) monitoring of at least two females, two males and their offspring to predict periods of high risk.

Periods of high risk can be predicted 9-15 months after a litter is born to one of the two females that use the Basin. Such periods have been least likely in summer since six of seven recorded litters have been born between August and February. During such risk periods, priority should be given to interpretive programs, collaring subadults and monitoring locations of mountain lions in the Basin. Trail closures may be necessary for transition periods while subadults are in the process of dispersal and more likely to encounter humans. Useful educational channels were the park newspaper (El Paisano), ranger talks and signs at trails.

In cases where visitors had been warned and educated how to behave, encounters with mountain lions did not result in injury. This may be the best approach to reduce risk and enhance visitor safety, since the approach of a mountain lion can never be predicted with certainty, nor have fail-safe deterrents been identified. Residents of the park need to be involved in mountain lion safety education as well as visitors, since they have children and pets.

Response by park personnel to incidents of reported attack has been prompt and appropriate. The decision-making process currently used is diagrammed in Figure 17. It involves three phases, an initial response to the

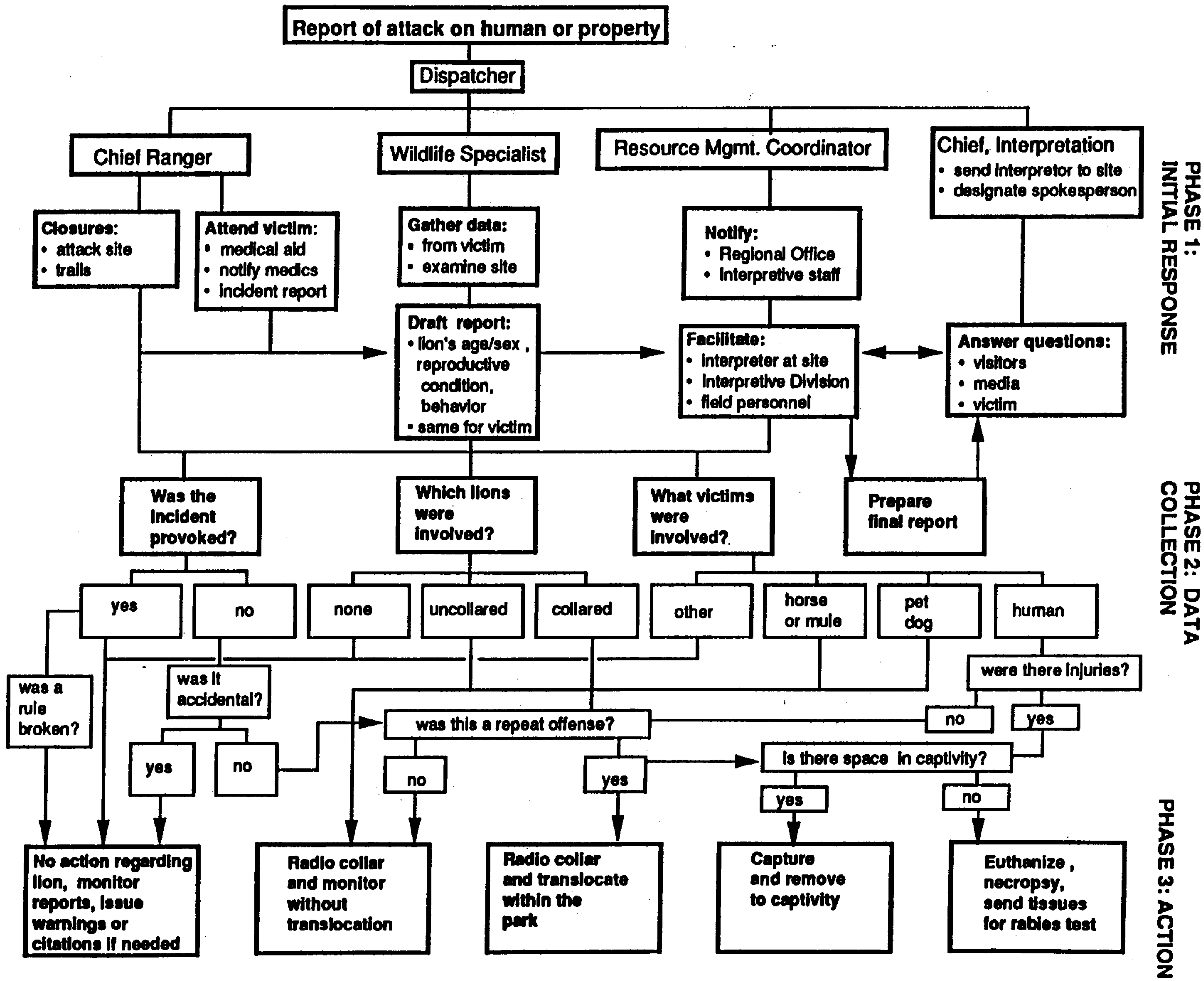

Figure 17. Recommended actions in the event of a reported incident of damage by mountain lions to humans or their property (redrawn from Ruth 1991).

victim and a phase of data collection prior to action. When the attack has resulted in injury to a human, the mountain lion has been captured and killed. Incidents not resulting in injury have alerted researchers to capture and collar mountain lions for closer monitoring. In cases of repeated incidents cause by one individual, the decision of action takes more judgement. Relocation within in the park is a non-lethal option if no space is available in captivity. However, factors increasing the probability that a translocated animal remains at the site of release are complex and poorly understood.

McBride and Ruth (1988) recommended a policy of sterilization of all adult female mountain lions using the Basin. This reduces the probability of subadults using the Basin during periods of dispersal from the natal area. Even if a management action such as sterilization of females is attempted, it will be extremely important to continue the monitoring program. Aerial telemetry is recommended due to the mountainous terrain. Daily ground searches should be conducted when a female is located near a male (indicating estrus) or near a den site. This information can be used to predict periods of high risk.

The long term data set resulting from telemetry studies in Big Bend National Park is rare and extremely valuable. Particularly in such situations where many factors (eg. season, nutritional condition, reproductive condition, prey vulnerability) influence the predictability of mountain lion movements, generalization is difficult. For example, an unidentified mountain lion appears to have moved into the Chisos Basin after the death of the Basin female (F05). Her movements may differ from the previous female. Few studies have followed individuals for the duration of the Big Bend study. This has yielded information on reproduction, dispersal, immigration, tenure of home ranges and mating patterns. Such information is needed to assess the impact of management actions on viability of the mountain lion population in the park. The viability of other predator populations has been reduced in other national parks when genetic isolation has occured in combination with changes in vegetation and prey populations, (Fergus 1991; Wayne, et al. 1991).

One of the difficulties of making predictions in the Big Bend environment is the variability of seasonal rainfall patterns. A study of prey movements and vulnerability to predation is highly recommended. The hypothesis that the Basin is a refuge of available prey for mountain lions during periods of stress needs to be examined. Possible shifts in distribution of the stationary white-tailed deer and small mammals that use the Basin need to be compared with mobile species such as the mule deer in the desert habitats surrounding the Basin. In addition, shrub vegetation has increased due to fire suppression and succession. The detailed studies of the movements of mountain lions have identified key questions that are beginning to reveal how the ecosystem works. Such understanding of ecological processes will be very important, particularly if reintroductions of other vertebrate species are to be considered in Big Bend National Park.

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