Stratton Mountain Black Bear Study

The Effects of Resort and Residential Development on Black Bears in Vermont

Final Report

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Vermont Agency of Natural Resources
Department of Fish and Wildlife

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CHAPTER 1

INTRODUCTION

The black bear (*Ursus americanus*) is native to Vermont and is found primarily in remote, forested habitat. An estimated 3,500 black bear live in the state with the majority occurring in the northeast counties of the "Northeast Kingdom" and in the Green Mountain chain running north and south through the center of the state.

Beginning in the 1980s, the Vermont Fish and Wildlife Department (Department) initiated a program of conserving black bear habitat under Vermont's Act 250 Land Use and Development Control Law (Title 10, Chapter 151, of the Vermont Statutes Annotated). Act 250 was created to protect the unique natural and rural qualities of Vermont. Criterion 8a of section 6086 (November 1, 1985 edition) addresses wildlife concerns and protects "necessary wildlife habitat decisive to the survival of" species which depend upon the habitat. This landmark legislation laid the foundation for the Department to actively protect critical wildlife habitat in the state.

Black bear habitat management in the Green Mountain State is based on the premise that minimum habitat requirements must be maintained. These requirements are adequate food supplies, forest blocks that meet home range needs, and connectivity to large blocks of forestland that serve as population sources. Vermont wildlife officials determined that three types of black bear habitat are critical and deserving of Act 250 protection. They are: 1) hard mast stands (oak and beech); 2) wetlands; and 3) travel corridors. Through efforts to protect these critical habitats, the Department attempts to maintain buffer zones between land development and the significant habitat of up to a ½ mile in width.

Ski area expansion and development is occurring at a rapid rate throughout the state and usually takes place within mountainous terrain also favored by black bears. In recent years, ski areas have undergone significant changes as they began evolving into year-round recreational destination areas rather than just winter resorts. Some now boast of more visitors during the summer months than during the winter. What was once an activity that had relatively few impacts to wildlife now has the potential to fragment large areas of wildlife habitat and displace many native species including the reclusive black bear.

Rapid mountain resort expansion has conflicted with the State's attempts to protect critical black bear habitat in past years. In some cases, decisions on whether resort development should be allowed to impact important black bear habitat have been hotly contested and required decisions from Vermont's Supreme Court and Federal district courts.

Rather than oppose state regulatory agencies, The Stratton Corporation (Stratton Corp.), owner of the Stratton Ski Area, has attempted to strike a balance between ski area growth and high standards of environmental quality. In particular, they sought a mutually beneficial compromise related to bear habitat. In 1988, they contacted the Department and requested assistance in developing expansion plans that called for nearly 500 new housing units, a second

18-hole golf course, a shooting range, and various other recreational facilities in bear habitat. State wildlife biologists working with ski area planners, modified the plans to avoid as much bear habitat as possible and then created a Memorandum of Agreement (MOA) that outlined various mitigation measures that Stratton Corp. would undertake to lessen impacts to the resident black bear population while undertaking some ski area expansion.

During the process of reviewing the proposed development, it was recognized that some of the predicted impacts of the development on bears were assumptions based on scientific research conducted elsewhere that deserved further testing in Vermont. As a result, Stratton agreed to partially fund a study designed to monitor black bear activity and behavior in relation to increased recreational and construction activity. In particular, the study would evaluate buffer distances needed by black bears in areas of different types of human activities. It was intended that the results of the study would shed additional light on what is “necessary habitat” for Vermont’s black bear population and provide a framework for including black bear habitat requirements in future mountain resort development plans throughout the state.

This study, termed the “Stratton Mountain Black Bear Study”, was initiated in 1989 by the University of Massachusetts. The Department took over the project early in 1990 after the unfortunate death of the principal investigator, Dr. Mark Sayre.

This final report is a compilation of data obtained from radio-instrumented black bears in southern Vermont. Included are portions of two M.S. Theses written by students who worked on the Stratton Mountain Black Bear Study. We intend to have topics from several of the chapters within this report published in peer-reviewed journals as time allows.

CHAPTER 2

THE STUDY AREA

The Stratton Mountain Black Bear Study Area is located in the Green Mountain range of southern Vermont in the counties of Bennington and Windham (Figure 2.1). The 260 km^2 area is centered on Stratton Mountain within the town of Stratton and also includes parts of the townships of Jamaica, Peru, Somerset, and Sunderland. Slightly more than half of the area is within the Green Mountain National Forest while the remainder is privately owned with the largest landowner being the Stratton Ski Area. Most of resort and residential development is on privately owned land on the eastern half of the study area in an area criss-crossed with minor paved and gravel roads (Figure 2.2). Less intensive monitoring of study animals was done on animals straying outside the core study area into the towns of Arlington, Dover, Glastenbury, Londonderry, Manchester, Searsburg, Shaftsbury, and Woodford in a larger area bordered by U.S. Route 7 on the west, Routes 11 and 30 to the north, Routes 30 and 100 on the east and Routes 100 and 9 to the south.

Tourism and the ski industry are two major sources of income to the region with the Stratton Ski Area and nearby Bromley and Mount Snow/Haystack Ski Areas attracting hundreds of thousands of visitors each year as the area is within a five hour drive of 40 million people. Dispersed recreation in the form of hiking, fishing, and regulated hunting, including the hunting of black bears, is also popular throughout the study area.

Elevations range from a high of 1201 meters at the summit of Stratton Mountain to 210 meters at the western edge of the study area within the town of Jamaica. The entire Study Area is within Wildlife Management Unit (WMU) P and is 92.5% forested. Approximately 44% of the Study Area is composed of mixed hardwoods, 38 % is coniferous forest, 1% is wetlands and 3% is agricultural and developed lands (J. Tinker, 1992). Forest cover types include northern hardwoods, mixed hardwoods, hemlock, and spruce-fir (DeGraaf et al. 1989). There was no distinguishable alpine zone within the Study Area and the highest elevations, roughly above 950 meters, are dominated by red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*). Common hardwood species in the Study Area include sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), and hemlock (*Tsuga canadensis*). Striped maple (*Acer pensylvanicum*), hobblebush (*Viburnum alnifolium*), raspberries (*Rubus* spp.), blackberries (*Rubus* spp.), serviceberry (*Amelanchier* spp.), and mountain maple (*Acer spicatum*) are common shrubs and small trees. Characteristic ground flora of higher elevations are clintonia (*Clintonia borealis*), bunchberry (*Cornus canadensis*), wood sorrel (*Oxalis montana*), wood ferns (*Dryopteris* spp.), and shining club moss (*Lycopodium lucidulum*). At lower elevations common ground flora include spinulose fern (*Dryopteris spinulosa*), hayscented fern (*Dennstaedtia punctilobula*), red trillium (*Trillium erectum*), whorled aster (*Aster* spp.), Canadian mayflower (*Maianthemum canadense*), trout lilies (*Erythronium americanum*), and sarsaparilla (*Aralia nudicaulis*).

Black bears share the forests of southern Vermont with other wildlife species. Ungulates present include moose (*Alces alces*) and white-tailed deer *(Odocoileus virginianus*). Small to mid-size carnivores present include coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and fisher (*Martes pennanti*). Although pine marten (*Martes americana*) were re-introduced to the area in the late 1980s, they are not believed to be present in any numbers.

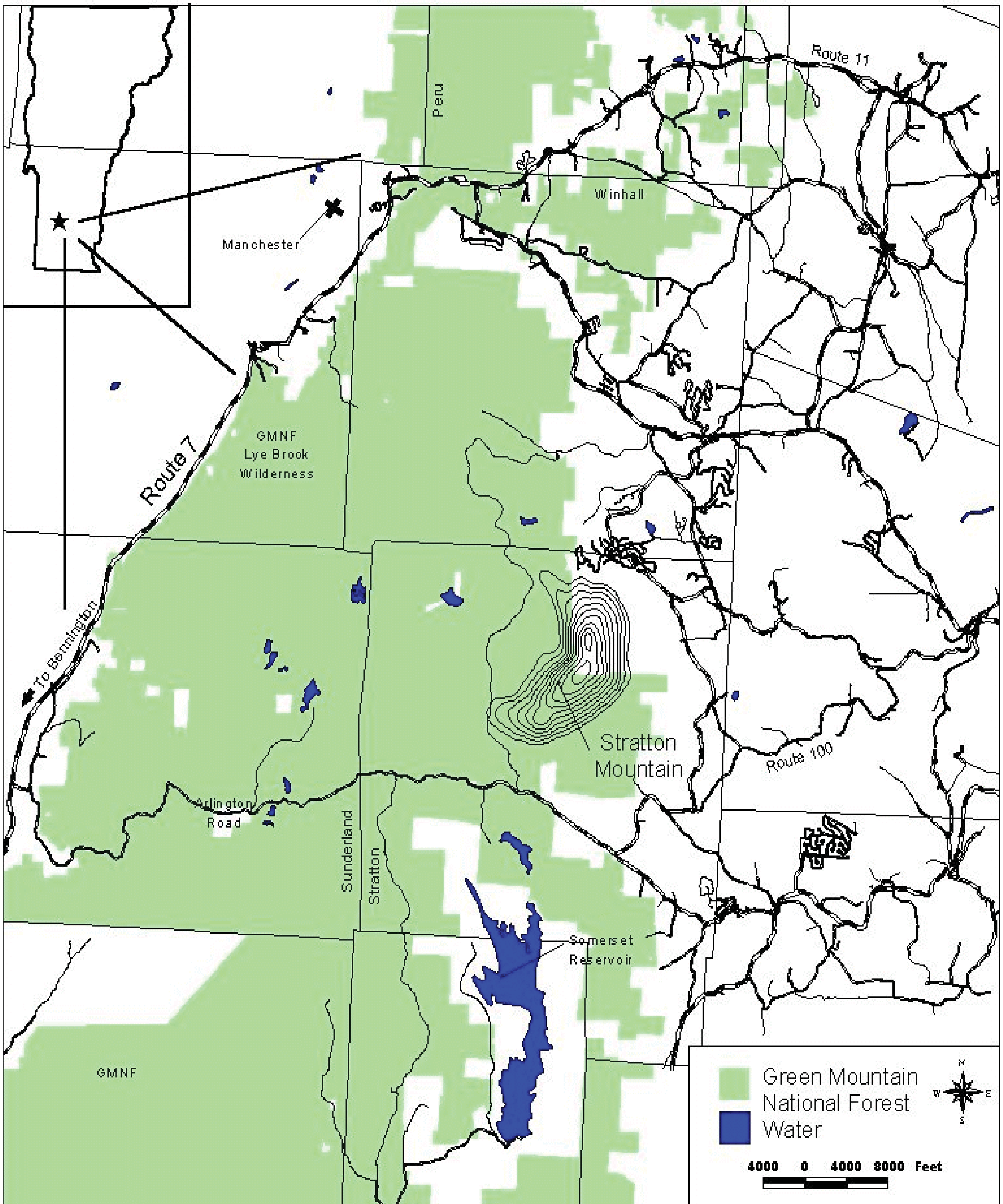

Figure 2.1. Location of Stratton Mountain Black Bear Study Area in southern Vermont

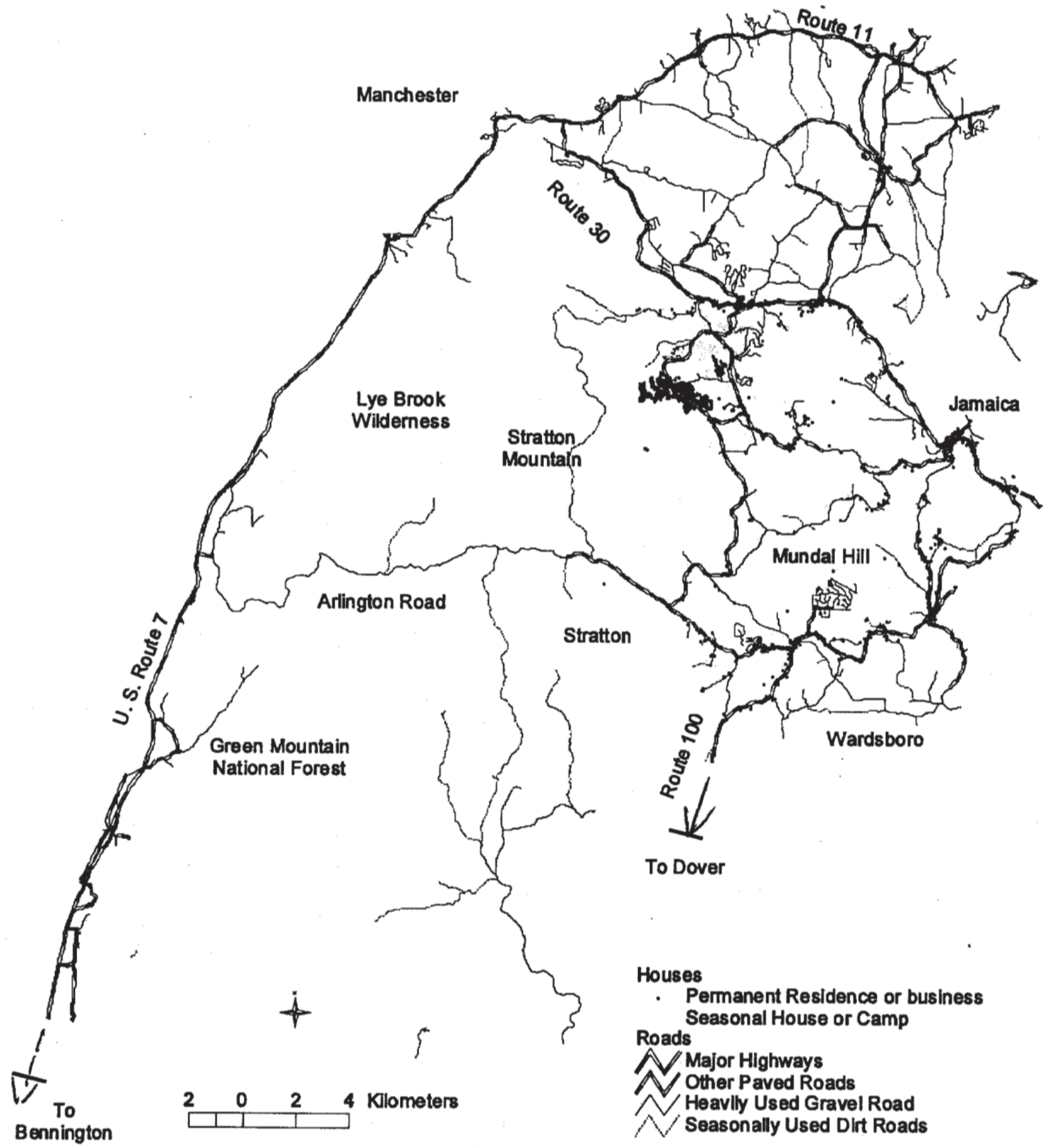

Figure 2.2. Cultural features found within the Stratton Mountain Black Bear Study Area south of Route 30, 1990-1995.

CHAPTER 3

BLACK BEAR CAPTURE PROGRAM

CAPTURE METHODS

Black bears were opportunistically captured to instrument them with radio collars from 1989-1995. The most intensive capture efforts were conducted May through July with additional attempts made throughout the field season to capture specific animals and to recapture those that had either pulled off their collar or had their radio transmitter fail.

We captured bears using Aldrich foot snares (Aldrich Spring Activated Animal Snare, Callum Bay, Washington 98326) or with the aid of trained bear dogs (Willey 1980). Our objective was to capture and instrument radio collars on the majority of the black bears whose movements and home ranges included Stratton Mountain and the immediate vicinity. Although males were captured and collared, especially during the first years of the study, our primary efforts were in capturing resident females. Our intention was not for this to be a population study where large numbers of study animals are desired, but rather a research effort focusing on intensive monitoring of a smaller number of animals in a more focused area.

The location and intensity of capture efforts varied in response to the location and number of adult females being monitored. Initial capture sessions were designed to capture as many animals as possible but, following the first year, capture efforts were concentrated in areas where females had not previously been captured.

Pre-baiting was done at snare sites and the actual snare not set and monitored until a bear was beginning to take the bait. Two widely-spaced snare sets were placed at each site in the event that multiple bears visited it together. To reduce the chance of snared animals injuring themselves, drag logs were not used and snare cables were securely attached to the bases of live trees at least four inches in diameter.

Two dog breeds used primarily in locating and capturing study animals were Plott Hounds and Walkers. We attempted to lessen the overall impacts of the capture program by not attempting capture with the trained hounds in areas where telemetry checks indicated there were collared bears present. After the hound pack had successfully treed a bear, two rectangular, braided nylon safety nets (3.66 x 6.10 meter) were erected under the tree prior to any immobilization actions. The bear's safety was the main concern; therefore, if conditions were not conducive to a safe capture, immobilization was not attempted.

Captured bears were chemically immobilized using Ketamine/Rompun (Ketamine hydrochloride + Xylazine hyrochloride) and the bottom right first premolar extracted for age determination purposes using cementum annuli counts (Stoneberg and Jonkel 1966, Willey 1974) on animals more than one year of age. Each was given metal identification tags in both ears and fitted with radio-transmitter collars (Telonics, Inc., Mesa, AZ 85204) modified with leather break-away segments. Collars were fit to allow for normal growth. Decay of the leather segments ensured collars would fall off in the event of transmitter failure. Radio collars were placed on all adult (> 4 years-old), subadults (2-3 year-olds), and yearlings (1 year-old).

Physical measurements were taken on each bear and notes recorded on the reproductive status and overall condition of the animal. Body temperatures were monitored with a digital rectal thermometer after the first capture season.

We visited dens of radio-collared bears to replace collars, record physical condition, and check for offspring. Yearling cubs were collared and eartagged, but newborn cubs were not marked. A spring check on cub survival was conducted in late April or early May prior to leafout and when the mother and cubs had left the den.

The capture and marking methods and techniques described here were reviewed and approved by the Animal Care and Use Committee at the University of Vermont in 1990.

RESULTS AND DISCUSSION

Capture Success

Fifty-two individual black bears over one year of age were captured between June 1989 and June of 1995 (Appendix A). The majority were caught using trained bear hounds, while the remainder were caught in snares and as yearlings in their dens (Table 3.1). A total of 57 captures was made with hounds including 22 recaptures in an estimated 150 attempts. Only nine bears, all males, were captured in snares and there were no recaptures (Table 3.2).

Most of the first field season was spent in trying to capture study animals. Thirteen bears were caught and radio-collared in the first two months of the study. Technicians from the University of Massachusetts conducting the initial capture operations were the first to comment on the wariness and difficulty in capturing bears in the Stratton Mountain region. They had been also capturing bears for studies in northern Massachusetts where success rates using both snares and hounds were much higher. Thirteen study animals provided a sufficient sample size to begin monitoring in April, 1990. Unfortunately, by the next spring attrition from regulated hunting, natural mortality, and bears pulling their collars off left only eight transmitters operating. Trying to maintain 12-16 operating collars proved to be an almost continuous effort that required over 100 days with hounds and more than 1200 snare nights over the next 6 years.

Attempts to snare bears were only partially successful and required much effort and time. Capturing bears, especially females, was more productive and efficient with trained hounds. Eventually, snaring was only attempted after extensive pre-baiting and in areas of heavy road traffic where using hounds was impractical.

Table 3.1. Method of capture used in initially capturing 51 individual black bears marked as study animals in the Stratton Mountain study, 1989-1995.

Capture Method	**No. of Bears Captured**			
	Male	**Female**	**Total No.**[a]	**Percent of Total**
Hounds	22	17	39	76.5
Snares	9	0	9	17.6
Den	1	2	3	5.9

[a] *One additional male was initially captured in Massachusetts but spent most of 1991 in Vermont.*

Table 3.2. Black bear capture effort and success from 1989-1995. Stratton Mountain Study Area, Vermont.

Characteristic	**Year**							**Total**
	89	**90**	**91**	**92**	**93**	**94**	**95**	
No. days with hounds	unk.[a]	22	35	27	13	11	1	109+
No. captures with hounds	11	7	13	12	7	6	1	57
No. of recaptures with hounds	0	2	8	8	0	3	1	22[b]
Snare nights	unk.	160	815	127	75	30	0	1207+
No. snare captures	2	0	2	2	2	1	0	9
No. snare recaptures	0	0	0	0	0	0	0	0

[a] *1989 capture effort data incomplete.*
[b] *Most (18) recaptures were to replace radio collars.*

Using hounds as a capture technique had its own set of advantages and disadvantages. Many bear crossing areas and feeding sites were first identified by the hounds while searching for bears to capture. A typical capture day, however, usually started before 4:00 a.m. and often continued until after dark trying to find lost dogs. Often a capture was not attempted because we were unable to locate a new bear to run during the early morning hours while it was still cool enough to attempt a chase. A total of 57 bears were treed out of 91 started, of which 46 were captured (Table 3.3). Some bears could be caught by the hounds and took a stand on the ground or in ledges. With difficulty, we captured 6 bears in this manner.

Immobilizing bears that had been run by hounds was more difficult than with most capture methods as the bear was often high up in a tree among thick branches or else swiftly descending the tree trying to escape. Under these conditions it was difficult to judge the weight of the animal correctly and prepare the immobilization drug and delivery system while the bear was still in his tree. Often the animal was so excited that the capture dose was insufficient. At least nine bears were missed for these reasons in the first few years of the study (Table 3.3).

Three mortalities occurred during capture operations. Two involved subadults who each died within three days of their capture. Both captures followed extensive chases with hounds and eventual chemical immobilization took place at high ambient temperatures. Both bears were kept cool after immobilization, but eventually died within a mile of the capture site. Cause of death was determined to be a combination of capture myopathy and heat stress. The third mortality was an adult male who was struck and killed by an automobile while we were attempting to capture him with hounds. Partially-healed injuries indicated he had survived a previous recent collision with an automobile. No mortalities were documented from other capture methods or during collar replacement during winter den visits.

Table 3.3. Summary of capture efforts using trained bear hounds, 1990 to 1995.

Year	No. of Days Attempted w/Hounds	No. of Bears Started	No. of Bears Treed	No. of Bears Started but not Treed	No. of Days None Started	No. of Bears Captured	No. of Bears Caught on Ground	No. of Times Researcher Missed or Drug Failed
1990	22	18	9	9	6	7	1	3
1991	35	29	19	10	8	13	2	5
1992	27	22	15	7	6	12	0	1
1993	13	10	5	5	3	7	2	0
1994	11	11	8	3[a]	2	6	1	0
1995	1	1	1	0	0	1	0	0
Totals	**109**	**91**	**57**	**34**	**25**	**46**	**6**	**9**

[a] *One large male bear was struck and killed by a car while being chased by hounds.*

CHAPTER 4

DEMOGRAPHICS

INTRODUCTION AND METHODS

Knowledge of black bear numbers, demographic characteristics, and population trends are essential components of bear management programs because bears are susceptible to over harvest and development pressures on their habitat. Females vary in their age at first breeding, size of litter produced, and in the sex ratio of litters (Kolenosky and Strathern 1987). Also, poor nutrition may result in delayed first estrus, increased incidence of barren females, smaller litter sizes, longer intervals between litters, and increased cub mortality (Jonkel and Cowen 1971, Alt 1989, Elowe and Dodge 1989, Noyce and Garshelis 1992).

In an investigation of 101 black bear litters in Minnesota, Noyce and Garshelis (1992) determined that weight and growth of cubs and yearlings were closely related to mother's size. They also observed that cub survival was affected when mother's weight 2 months postpartum was below 65 kg. Litters of females that were below this minimum weight threshold had a reduced chance of survival. In both Pennsylvania and Minnesota, researchers found litter size largely unaffected by maternal weight except that the heaviest females (those over 100 kg.), generally were the mothers that produced litters of 4 and 5 cubs (Alt 1989, Noyce and Garshelis 1992).

Cub mortality rates vary widely among black bear populations across North America. Most natural mortality in cubs and juveniles has been reported within 3 months after leaving the den (Rogers 1987, Elowe and Dodge 1989, Beck 1991, Schwartz and Franzmann 1991). This time period has particularly high energy costs for bears as the green vegetation that bears generally rely on in early spring is lower in digestible energy than summer and fall foods (Pritchard and Robbins 1990).

Although this study was not designed specifically to examine population characteristics, capturing black bears to radio-collar involved handling many animals, especially as attrition due to collar loss forced researchers to continue an aggressive capture program. Information on reproductive characteristics such as age of first reproduction, interbirth interval, litter size, and cub sex ratios were obtained when replacing radio collars on adult females in their dens during March. Cubs not present in the den with their mothers as yearlings were assumed to have died. Adult mortality sources were determined through monitoring radio-collared bears.

Radio-collar transmitters were designed to emit a "mortality" signal when they were stationary for more than two hours. All transmitters emitting a mortality signal were ground tracked to determine whether the signal was an actual mortality or a "dropped" collar that the study animal had somehow pulled off.

Hunting season mortalities of marked bears were recorded through the Department mandatory reporting program. Collars on adult males were removed during den checks in 1995 and from adult females in 1996 during the terminal stages of the data collection efforts.

RESULTS

Age Structure and Weights

Our age sample of 49 individual black bears was comprised of 61% males and 39% females. Median ages of males at capture was 3.8 years and varied from 9 months to 13 years-old (Fig. 4.1.) Median ages of females at capture was 4.8 years and varied from 8 months to 15 years-old. Forty-three percent of males and 42% of the females were adults (≥4 years) when first captured. The oldest bear monitored was a female that was 18 years-old when her collar was removed at the end of the study. The oldest male bears were two that died at age 15 (one from being killed by a hunter and the other from unknown causes) and another male that was also 15 years-old when his collar was removed in 1995.

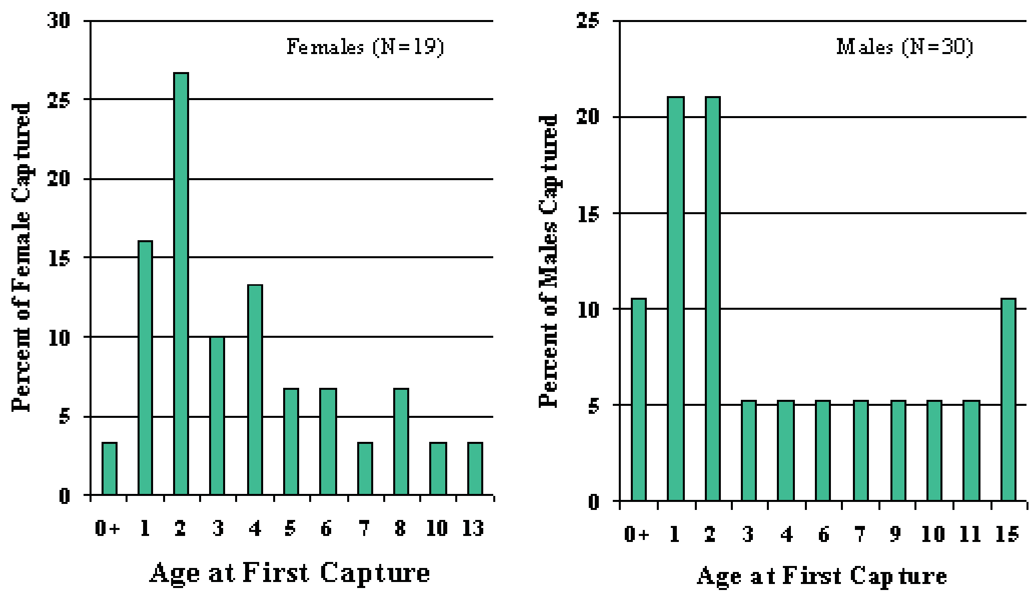

Figure 4.1. Age structure of 49 black bears captured in the Stratton Mountain Study Area between 1989 and 1995.

The weights of black bears varied greatly between individuals at the time of capture due in part to the different times of year when they were first captured. The mean weight for adult males was 175 pounds while that of adult females was 112 pounds (Table 4.1). The largest male was 240 pounds when first captured in July and weighed 302 pounds when weighed at his den site in February. The smallest adult male was 135 pounds at the time of his capture in June as a 4-year old. Adult females were captured June through September, with one being first captured at her den site. The heaviest adult females (2) weighed 125 pounds when first captured and the lightest 90 pounds. The heaviest female monitored during the study was a 160 pound 12-year old when weighed in March following an exceptional food production year. Her den weight the following year, after a particularly poor food year, was only 85 pounds.

Table 4.1. Selected morphological measurements of subadult and adult black bears in the Stratton Mountain Study Area, 1989-1995. Measurements given are in pounds and inches and are from the initial capture of each animal.

Measurement	Male		Female	
	Subadult[a] (N=12)	**Adult[b] (N=14)**	**Subadult (N=5)**	**Adult (N=8)**
Weight	115.7	174.6	96.4	112.0
Front Pad Width	4.0	4.4	3.3	3.8
Neck Circumference	18.8	22.4	17.0	19.2
Zoological Length *(includes tail)*	54.5	57.2	44.8	52.2
Chest Circumference	31.7	36.0	29.1	30.5
Height	27.1	29.9	22.4	26.3

[a] *Subadult = 2 & 3-year old*
[b] *Adult = $\geq$4 year old*

Reproduction

Between 1990 and 1996 we documented the birth of 38 cubs from 17 litters of radio-collared female black bears (Table 4.2). Mean litter size was 2.2 cubs. Most litters consisted of 2 cubs (47%), followed by litters of 3 (29%), and 1 litter each of 1 and 4 cubs. Of the 16 litters where gender of cubs was known, the sex ratio was 51% female and 49% male.

Table 4.2. Natality and survivorship of cubs during the Stratton Black Bear Study, 1990-1996.

ID No.	Year	No. of Young	Cub Sex F/M	Age of Mother	Survivorship
15	1996	3	2/1	13	Unk[a]
28	1996	3	1/2	16	Unk[a]
50	1996	3	2/1	10	Unk[a]
50	1995	2	1/1	9	0/0
41	1995	4	2/2	17	0/0
15	1995	1	1/0	12	0/0
28	1994	2	1/1	14	1/0
15	1994	1	0/1	11	0/1
10	1994	1	1/0	6	Unk[b]
15	1993	2	1/1	10	0
25	1992	2	2/0	5	Unk[b]
28	1992	2	2/0	12	1/0
13	1992	2	1/1	6	0/0
19	1992	2	0/2	12	0/1
15	1991	3	1/2	8	0/2
13	1991	2	0/2	5	0
2	1990	3	Unk	10	Unk[c]
Total	**17**	**38**	**18/17** $\bar{X}$ **= 2.2**		**6 of 23**

[a] *Researchers removed sow's collar at natal den at the completion of the study*
[b] *Sow removed own collar prior to denning*
[c] *Sow killed by hunter*

The reproductive histories of 6 female black bears was positively ascertained through age 4, 4 through age 5, and 1 through age 6 for purposes of determining age of first cub production. None of the 6 females produced cubs at age 3 or 4 (0%), and 2 of 4 females first produced a litter at age 5 (50%). One monitored female finally produced a single cub at age 6.

Eight complete interbirth intervals were documented for 4 female black bears. Four of these intervals were compromised by loss of a complete litter where the female must have lost the litter early enough to breed and produce another litter the following year. The mean interbirth interval was 1.4 years and varied from 1 to 2 years (Table 4.3). One 12 year-old female was observed in her den in early March with a yearling male as well as a newborn female cub.

Table 4.3. Reproductive history of female black bears monitored during the Stratton Black Bear Study, 1990-1996. Data recorded during annual den visitations in the month of March.

Reproductive Event (females ≥ 4 years)	Value	Sample Size (N)	Range
Litter size	2.2 cubs	(17)	1-4
Sex of cubs	51F:49M	(6)	
Percent of 4-year olds producing young	0%	(3)	
Percent of 5-year olds producing young	66⅔%	(32)	
Mean age of adult females	9.1 yrs.	(23)	4-18 yrs.
Mean weight of adult females	107.3 lbs.	(13)	85-160
Mean weight of productive females	125.1 lbs.	(10)	110-160
Mean weight of females in year following giving birth to cubs	100.7 lbs.	(5)	85-142
Mean weight of females when no cubs survived coming year	125.6 lbs.	(4)	113-140
Mean wgt. of females when any of litter survived coming year	137.7 lbs.	(5)	122-160
Mean wgt. of females who had cubs survive previous year	106.6 lbs.	(6)	85-135
Mean weight of females in year following loss entire litter	121.8 lbs.	(5)	105-142
Mean weight of females in year of litter loss	125.6 lbs.	(8)	113-14
Mean interbirth interval	1.4 yrs.		1-2

Our small sample size and the short duration of the study prevented us from determining statistically meaningful reproductive rates or data on the end of reproductive activity in older black bears. The oldest female monitored also produced the largest litter, a litter of 4 cubs at age 17.

The mean weight of females producing cubs was 125.1 pounds (N=13). No female checked in her den in March weighing less than 110 pounds had newborn cubs (Table 4.4) with her.

Cub Survivorship

We were able to determine cub survivorship in only 11 of the 17 litters (23 of 38 cubs) due to our removing collars at the end of the study before survivorship could be determined (3), mothers removing collar prior to denning with cubs (2), and the sow being shot during the hunting season (1). Cubs were lost in 10 of the 11 litters (91%), and entire litters in 6 (54%) of them. Only 6 cubs, 2 female and 4 male, were observed denning with their mother as yearlings for a survivorship rate of only 26%.

Table 4.4. Adult female black bear ages and weights in southern Vermont in relation to reproductive performance. Weights are in pounds at time of den visit in early March.

Identification Number	Age	No. of Newborn Young	No. of Yearling Cubs	Female Weight	Year
2	10	3	—	—	1990
5	4	0	—	102	1991
5	5	0	—	—	1992
10	4	0	—	—	1991
10	5	0	—	93	1993
10	6	1	—	113	1994
13	4	0	—	85	1990
13	5	2	0	115	1991
13	6	2	0	125	1992
15	8	3	—	—	1991
15	9	0	2	—	1992
15	10	2	—	113	1993
15	11	1	0	142	1994
15	12	1	1[a]	135	1995
15	13	3	0	122	1996
19	11	0	1	108	1991
19	12	2	0	160	1992
19	13	0	1	85	1993
25	4	0	—	—	1991
25	5	2	—	115	1992
28	12	2	—	127	1992
28	13	0	1	95	1993
28	14	2	—	—	1994
28	15	0	1	110	1995
28	16	3	—	110	1996
38	4	0	—	—	1993
38	5	0	—	95	1994
41	17	4	—	140	1995
41	18	0	0	105	1996
48	4	0	—	90	1996
50	8	2	—	—	1995
50	9	3	0	110	1996

[a] *In 1995 female No. 15 produced a cub while denned with a yearling cub.*

Exact cause of death was not determined for any of the 38 cubs. We recounted cubs in early May prior to leaf-out and observed only two missing from the March den counts. Most females (83%) that lost entire litters were observed with cubs the following March which indicates that most cub mortality was occurring during the late spring and early summer periods, enabling the female to enter estrus and breed before the end of the breeding season. Only one female that lost an entire litter was observed the following March without newborn cubs.

Females produced litters of cubs every year of the study despite only two years of food abundance in the late summer and fall seasons. Litters were produced in poor as well as good food production years (see Chapter 5). There was no indication that females synchronized cub production following years of good mast production.

Mortality

We documented 44 black bear mortalities (Table 4.5), 16 which were females (36%) and 28 males (64%). Cubs less than a year old comprised the largest class of mortalities with 18 known to have died. The known mortality rate for first year cubs was 74%. Cubs were not radio collared and so exact cause of death could not be determined. Two bears, both yearling females were capture mortalities. One large adult male was struck and killed by an automobile while two others were known to have survived collisions with cars. The only mortality from other bears was of a 2-year old male that was pursued up a small maple tree by a larger bear and dragged out and eaten during early June. Two large adult males were found dead in early spring of unknown causes soon after leaving their winter dens. One was found in close proximity to a highway and may have sustained fatal injuries from a collision with an automobile. The other adult male was found in a remote spring feeding area, but cause of death could not be determined because of the advanced state of decomposition compounded by other bears having fed on the carcass.

Table 4.5. Cause-specific and class-specific mortality records for 44 black bears in the Stratton Mountain Black Bear Study, 1989-1996.

Sex	Age Class	Auto	Other Bear	Legal Hunting	Research Captures	Unknown	Total
Female	Cub	0	0	0	0	9	9
	Yearling	0	0	0	2	0	2
	Subadult	0	0	1	0	0	1
	Adult	0	0	4	0	0	4
	Combined	0	0	5	2	9	16
Male	Cub	0	0	0	0	9	9
	Yearling	0	0	0	0	0	0
	Subadult	0	1	9	0	0	10
	Adult	1	0	6	0	2	9
	Combined	1	1	15	0	11	28
Total		**1**	**1**	**20**	**2**	**20**	**44**

Regulated hunting was the primary cause of known mortality among both subadult and adult study animals (Fig. 4.2). It accounted for 79% of known causes of death in subadult and adult males (N=15) and for all of the adult and subadult female mortalities (N=5). Nine bears were killed during November by hunters whose primary quarry was deer, but 11 others (55%) were taken in September and October by bear hunters (Table 4.6). Nine of the bear hunters indicated that they killed the bear while still hunting or on stands and only two reported using hounds. All but one reported they used firearms to harvest the bears.

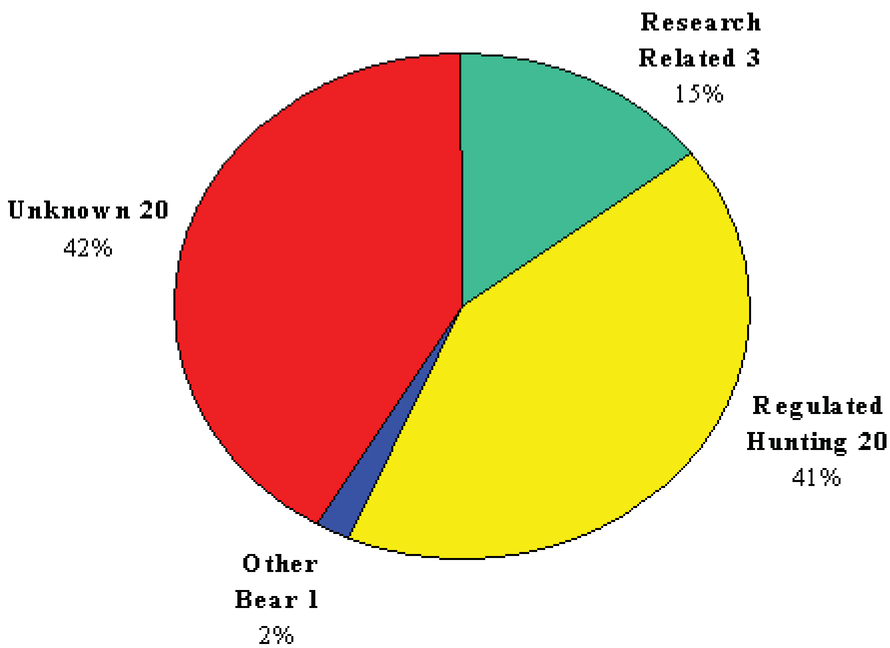

Figure 4.2. Cause of death of study animals in the Stratton Black Bear Study Area, 1989-1995. Unknown mortality sources are primarily for cubs.

Two of the hunting mortalities, a large adult and a subadult male, occurred in Massachusetts during their hunting seasons. The adult had been captured after it had been raiding garbage cans in a large residential subdivision in Wilmington, Vermont. After being captured, it traveled to a remote area of the Green Mountain National Forest where it spent two weeks before going south into Massachusetts where it was killed feeding in a cornfield. The young male was initially collared in northwestern Massachusetts before making a year-long foray into southern Vermont and through the Stratton Black Bear Study Area. It denned on the west shore of Harriman Reservoir in Vermont and returned to Massachusetts the following spring.

Table 4.6. Method of hunting and month of the year when 20 study animals were legally harvested. Stratton Black Bear Study, 1989-1995.

Method of Take	No. Killed	Month	No. Killed
Bear Hunting	11	September	5
With Hounds	2	October	6
Without Hounds	9	November	9
Archery	1		20
Muzzleloader	1		
Taken opportunistically while hunting deer	9		

DISCUSSION

Information gained on reproduction and mortalities while attempting to maintain radio collars on study animals indicated that black bears within the Study Area were slow to reach sexual maturity, were light in weight, and that newborn cubs had a very low survival rate. The number of cubs dying from unknown causes nearly equaled the number of subadults and adults taken by bear hunters. Although the causes of cub deaths were unknown, the poor condition of their sows suggest starvation may have been a key factor in their deaths. Predation by adult male bears may also have been a factor. The timing of cub loss was between den emergence and the end of the breeding season in August. Females were checked during early May and females that lost litters bore new litters the following January.

Many studies report female black bears commonly producing their first litter at age 3 (Alt 1981, Garshelis et al. 1988). In this study we did not document primiparous cub production before age 5. Overall, our observed cub production was in line with that reported elsewhere, but the survival rate was the lowest that we are aware of (Table 4.7). Our smaller sample sizes and short study time frame may have been partially responsible for this, but we believe that the Study Area has a low diversity of food species and few available agricultural fields to offset natural food shortages. Females seldom exceeded the minimum threshold body weight of 65 Kg., or 143 pounds, that other researchers have reported as influencing cub survivorship (Figure 4.3). Only one female, following a particularly good food year, exceeded the minimum weight that ensures a normal rate of survival. During years when natural foods are lacking (four of the six years of this study), black bears within the Wildlife Management Unit (WMU) that encompasses the Study Area do poorly. To test if light weights were common in other areas of the state, we compared mean weights and ages of hunter-harvested, adult females taken in the four southernmost counties with the three counties of the Northeast Kingdom. The mean ages were similar, but the carcasses of adult females from the northeast counties were nearly 10% heavier (Table 4.8), a difference in weight that may help them exceed the minimum weight threshold at two months postpartum. This weight difference could result in females in the north half of the state having higher cub survivorship and perhaps a higher rate of females producing their first litters at ages 3 and 4.

Table 4.7. Cub survival estimates for black bear populations throughout North America based on observation of mothers and their offspring during winter den checks.

State or Province	Survival rate	n	Citation
Wisconsin	0.94	18	Massopust (1984)
Minnesota	0.85	108	Garshelis et al. (1988)
Pennsylvania	0.84	90	Alt (1981)
Minnesota	0.75	181	Rogers (1977)
Massachusetts[a]	0.63	16	Fuller (1993)
Tennessee	0.62	29	Eiler et al. (1989)
Massachusetts	0.59	41	Elowe and Dodge (1989)
Colorado	0.56	39	Beck (1991)
Massachusetts[a]	0.53	17	Fuller (1993)
Ontario	0.53	32	Kolenosky (1990)
Arizona	0.52	23	Le Count (1987)
Vermont	0.26	11	This study

[a] *Data from two different study areas.*

Table 4.8. Mean weight and ages of hunter-harvested adult female black bears taken in the northeast and southernmost counties of Vermont between 1980 and 1996. Weights are in pounds and for field-dressed bears ages $\geq$4 years (Unpublished VTFWD data).

Region	N	Mean Weight	Mean Age (years)
Northeast[a] Counties	108	141.5	7.5
Counties of Study Area[b]	55	127.5	7.8

[a] *Caledonia, Essex, Orleans*
[b] *Bennington, Rutland, Windham, Windsor Counties*

Legal, regulated hunting was the primary cause of mortality among both subadult and adult study animals. It accounted for most of the known causes of death in males and all of those known for females as reporting is mandatory for licensed hunters. Fifty-five percent of the hunting mortality was from hunters hunting specifically for bears prior to the deer season. This number may have been under-represented as only two bears were taken by houndsmen. Most houndsmen knew of the Study and several reported treeing, but not shooting, collared bears.

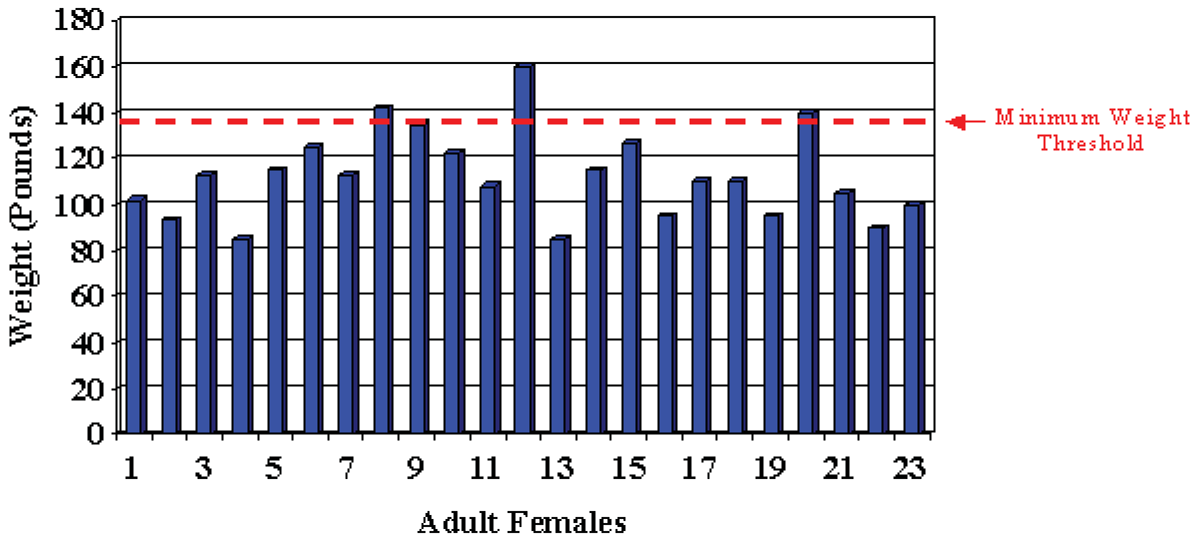

Figure 4.3. Weights of adult female black bears in the month of March, 1990-1996. Maternal weights below the Minimum Weight Threshold correspond to reduced cub survival (Noyce and Garshelis, 1992).

Only one bear, an adult male, was killed after being struck with an automobile. Two others were hit but survived their injuries. Another adult male was found dead approximately 200 meters from a highway, but cause of death could not be determined. As bear habitat becomes more fragmented by roads and traffic volumes increase, automobiles may become a major source of black bear mortalities in the future. Several studies have documented increases in highway mortality associated with increases in traffic levels and highway development. Road-kills in some counties of Pennsylvania, North Carolina, and Florida, for example, now exceed legal harvest by hunters. In these states road mortality may reduce local populations and be preventing the recolonization of unoccupied habitats (Wooding and Maddrey 1994, Cook and Daggett 1995).

Suboptimum body weights and low cub survival suggest that black bears within the Study Area (and within WMU P) have difficulty obtaining adequate nutrition during most years. The absence of agricultural lands within the Study Area may be partially responsible as researchers in Maine and Massachusetts report black bears rely heavily on feed corn, and maintain heavier body weights, during years when natural foods are lacking (McLaughlin 1998, McDonald 1998).

Population estimation was not within the scope of this study. Results, however, suggest that cub production in WMU P may be below that needed to sustain current hunting levels without ingress from other populations. This is inconsistent, though, with Department bear harvest data. Harvest numbers from this area have been consistently high without large fluctuations in the age structure that might indicate problems with recruitment or harvest levels that are unsustainable. Vermont wildlife biologists do believe that large numbers of bears immigrate into the southern region of Vermont from Massachusetts, but the high cub mortality figures may also reflect problems of working with small samples and several years of food scarcity that may not accurately portray long-term conditions.

CHAPTER 5

RESOURCE UTILIZATION

INTRODUCTION

Black bears, like other mammals, are not truly nomadic but instead tend to confine their activities to established areas called home ranges. William Burt (1943) defined a mammal's home range as the area over which the animal travels in its normal activities of food gathering, mating, and caring for young. He also defined territory as "any defended area". The overall availability of food determine home range and territory size. In general, increased availability of food leads to decreased territory size (Ebersole 1980, Hixon 1980, Schoener 1983).

The effects of food availability on territory size have not been well documented for black bears, but evidence to date suggests that food is the most important resource for black bears (Powell et al., 1996; Rogers 1976, 1977). Variations in food productivity may influence home range size as black bears sometimes travel long distances to find productive food patches when foods are scarce (Garshelis and Pelton, 1981; Garshelis et al., 1983; Rogers, 1977, 1987; Schorger, 1946, 1949). Most black bear researchers have reported extensive movements and changes in home range size as a result of variations in fall hard and soft mast production, but Powell et al. (1996), studying a bear population in western North Carolina, also documented annual and seasonal variations in response to yearly variations in productivity of squaw root *(Canopholis americana)* in the early summer.

Researchers have demonstrated that adult female black bears are territorial toward other adult females while exhibiting tolerance of their own immature female offspring (Rogers 1977, Ruff and Kemp 1980). Powell (1987) hypothesized that increased habitat productivity leads to decreased territorial behavior in adult female black bears. He documented extensive overlap among adult females, especially between mothers and their offspring.

In New England, black bears are dependent on food supplies that fluctuate widely in abundance, influencing their movements, reproductive success, recruitment, mortality rates, and levels of nuisance behavior (Elowe 1987, Elowe and Dodge 1989, Hugie 1982, McLaughlin et al. 1992, McLaughlin 1998). Nuts of the American beech *(Fagus grandifolia)* are believed to be the most important fall food and have been shown in Maine to be responsible for alternate-year cub production associated with alternate-year cycles of beechnut crop production and failure (Schooley 1990, McLaughlin et al. 1992). Populations with access to agricultural crops such as corn are more productive and have greater body weights than those populations dependent on wild foods (McLaughlin 1998, Elowe 1987).

McLaughlin (1998), expressed concern over the future of beech stands due to timber harvest practices and beech bark disease. He predicted that "the nutritional plane of female black bears and their reproductive rate would decline substantially if beech trees become rare in northern Maine." He also emphasized that the risk of beech trees being lost through disease or excessive timber harvest emerged as a major threat for black bear management in Maine.

In Vermont, Willey (1978) reported that spring foods include grasses, sedges, herbs, horsetail (*Equisetum spp.)*, acorns, beechnuts, evergreen needles, buds, roots, and carrion. During summer, bear diet includes jack-in-the-pulpit bulbs, soft mast such as berries and insects in addition to herbaceous vegetation. Hard mast and fruit including apples, cherries, blackberries, acorns, and beech nuts are the predominant fall food.

Researchers elsewhere have reported that early spring is a time of particularly high nutritional stress for bears (Elowe 1987, Eagle and Pelton 1983). Until succulent vegetation is available, bears continue to survive on the fat reserves that sustained them during the winter, and may continue to lose weight for a period of several weeks. Several studies (Landers et al. 1979, Reynolds and Beecham 1980, Elowe 1984, Rogers and Allen 1987, Hugie 1982) have reported that wetlands are a critical source of early spring foods for black bears. Elowe (1984) found that the activities of Massachusetts black bears centered around wetlands from spring emergence to mid-July. Furthermore, he found forested wetlands to be the single most important habitat component in determining home range size. Rogers (1987), found that forested wetlands supplied over half the early spring diet of bears in Minnesota, even though these habitats comprised less than 2% of his study area. Herbaceous vegetation found in forested wetlands, beaver impoundments, tamarack swamps, and riverine areas were the predominant food items used by Massachusetts bears. Skunk cabbage *(Symplocarpus foedidus)* in particular, was widespread and abundant in wetlands and in some years accounted for >80% of the volume of scats collected in the spring (McDonald 1998). In Pennsylvania, Hugie (1979) reported that forested and shrub-dominated wetlands composed only 5% of the land but supported 70-80% of the bears. In addition to providing critical spring foods, wetlands and riparian areas are important as escape and security cover, and for cooling during summer (Rogers and Allen 1987) as well as for travel corridors (Kellyhouse 1980, Elowe 1984).

METHODS

Monitoring Movements

Study animals instrumented with radio collars were monitored from July 1989 to March 1996. Locations were determined using a combination of triangulation (Nams and Boutin 1991) and homing in (White and Garrot 1990). Much of the study area is composed of rough terrain that made accurate hand-held telemetry difficult. Useable telemetry data was not collected until after 1989 when more rigorous telemetry methods were used. Beginning in 1990, azimuths were taken from known locations and immediately plotted onto 7.5 minute USGS orthophoto quadrangle maps. Each location was estimated to be in the center of the triangle created from the intersection of three bearings (Nams and Boutin 1991) and that location estimate recorded on a data form as a point using the Universal Transverse Mercator (UTM) coordinate system. Location points were rounded to the nearest 50 meters. To obtain the most accurate data points possible, we used location estimates only if they met the following criteria (Hellgren et al. 1991): 1) location estimate was <150 meters from observer and determined by at least 2 bearings taken by single observer and separated by at least 45 degrees; 2) location estimate was >150 meters from observer and determined using at least 3 bearings taken within 30 minutes by single observer and separated by at least 45 degrees; or 3) location determined by two observers taking simultaneous readings on a single animal separated by at least 45 degrees.

Monitoring of collared animals was most intensive from time of emergence from dens in spring until mid-fall. We assumed bears were able to traverse their entire home range within ten hours, so we used only one location in a 10-hour period for any given animal to insure independence of locations. Signal characteristics (steady/varying/erratic) were used to determine whether a bear was stationary, moving, or running. Locations were attempted on a daily basis for those study animals within the core study area and once a week for those outside the study area. Telemetry efforts were scheduled to begin each day in randomly-assigned quadrants of the study area during four different time periods designed to monitor the study animals during all periods of activity. During 1994 researchers monitored on a 24-hour-a-day schedule to document levels of nocturnal activity.

Telemetry Error

Animal locations obtained through triangulation are estimates, not true locations (White and Garrot 1986). Each bearing has error associated with it and, therefore, the intersection of bearings represents an area with an associated probability of containing the true location of the animal. The acceptable amount of error depends upon the particular objectives of the study (White and Garrot 1986). To determine the accuracy with which bear location estimates were obtained, telemetry error trials were conducted in 1991 and 1992 using transmitters placed at known locations at varying distances from roads. Amount of error varied between researchers and increased as the distance became greater between the researcher and transmitter. Mean bearing error and standard deviation of error ($\bar{x}$=5.23 degrees, SD=3.63) for the Stratton Mountain telemetry program were determined and reported by Betsy Glenn in her M.S. Thesis (Glenn 1993).

Home Range Analysis

In order to minimize possible autocorrelation between consecutive telemetry locations, it was assumed from knowledge of the movements of bears in the study area that any two locations more than 10 hours apart were independent. For any set of locations that were less than 10 hours apart, only the first location was used in the home range analysis.

Home ranges were calculated using the CALHOME home range analysis program (Kie et al., 1994). Both adaptive kernal (AK) and minimum convex polygon (MCP) home range estimates were generated for comparative purposes. One hundred percent contours were used for the MCP estimates, and 95% contours were used for the AK. A 50 x 50 cell grid was used in the AK model.

Outliers were removed by visual inspection of the home range plots. Any isolated locations which appeared far outside of the 100% MCP and 95% AK contours were considered outliers (due either to human error in recording the location or to an anomalous foray of a bear outside of its home range) and deleted from analysis. Only home ranges containing a minimum of 30 locations (after removing outliers and potentially autocorrelated locations) were analyzed by season. A total of 3,155 study animal location point estimates were used in our analysis.

Several home range plots showed distinct "satellite" clusters of locations separate from the main part of the home range. MCP estimates were calculated separately for these satellites and then added to separate estimates for the main part of the home range, rather than plotting a single home range contour encompassing both pieces including the unused habitat between them. No such adjustment was necessary for the AK estimates for these subdivided home ranges, other than a bandwidth adjustment where necessary (see below).

There were large discrepancies between the MCP and AK home range estimates for several females' home ranges. Most of the home ranges (7 out of 10) demonstrating such discrepancies had either weakly or strongly bimodal home range distributions, and it was suspected that these discrepancies resulted from sub-optimal selection of the bandwidth parameter by the CALHOME program. The ratio of the MCP home range estimate to the AK estimate (MCP/AK) was calculated to visualize which home ranges showed the strongest discrepancies. All of the home ranges with pronounced bimodality (as revealed by visual inspection of the 95% adaptive kernal contours) had ratios $\leq$73% or $\geq$127%. Therefore, all females' home ranges outside of these extremes were reexamined to determine the optimal bandwidth (i.e. the bandwidth which resulted in the lowest least-squares-cross-validation (LSCV) score). However, in some cases use of the optimal bandwidth resulted in fragmentation of the home ranges into multiple non-contiguous units, or produced home ranges containing multiple "holes." Therefore, manual calculation of the bandwidth entailed decreasing this parameter in progressively smaller increments until either: (1) the home range began to fragment into multiple pieces; or (2) the minimum LSCV value was attained, whichever came first. The resulting home range was then calculated from this bandwidth. For all other females, CALHOME was allowed to automatically select the optimal bandwidth.

Habitat use and habitat preference were determined using procedures described by Neu et al. (1974) and Byers et al. (1984) where an initial chi-quare comparison is combined with confidence intervals on observed use. In determining selection of Ecological Land Types (ELT's), we compared use to availability of the ELT's on an 843 km^2 of the Study Area that had been typed by the U.S. Forest Service (Mitchell 1988). Den sites were visited on foot in January through March. Collars were replaced on males and subadult females in January and February, while adult females were visited during March. At each bear den, elevation, slope, aspect, habitat type, and physical characteristics of the den were recorded. Den locations were plotted on USGS topographic maps and the UTM coordinates recorded.

Three foraging categories (spring, summer, and fall) were used for seasonal analyses and represented periods of distinct changes in the diet and activity of black bears. These season definitions were based on a combination of researcher observations on changes in food habitats, behavior, and food availability. Spring was defined as den emergence to 15 June, summers as 16 June to 30 August, and fall as 1 September to den entrance.

RESULTS

Home Range Characteristics

Forty-six annual home range sizes were determined for 26 different black bears monitored in southern Vermont during 1990 to 1995. Median home range size of adult females was 36.2 square kilometers and varied from 12.4 to a high of 72.6 square kilometers. Subadult female home ranges were only slightly larger than adult females with a mean of 42.9 square kilometers. Adult males' home ranges were larger with a mean of 158.1 square kilometers and ranging up to 391.5 square kilometers. Subadult males had home ranges nearly as large as those of adult males with a mean size of 145.2 square kilometers (Table 5.1).

Table 5.1. Summary of annual home range size for black bears in the Stratton Mountain Study Area, 1990-1995. Home ranges calculated using Adaptive Kernel (95% contour) method with autocorrelated points deleted. Size units are in km^2.

Age/Gender Class	Number of Individuals	Number of Ranges	Average Area	Std. Dev.	Range
Adult Female[a]	10	23	36.18	15.50	12.42-72.60
Adult Male	8	13	158.15	93.56	57.95-391.50
Subadult Female[a]	4	6	42.88	22.05	20.22-77.43
Subadult Male	4	4	145.19	138.88	16.00-302.00

[a]*Does not include fall dispersal data for years of fall food scarcity where the bear left its home range.*

Home ranges were significantly larger for both adult female (48.1% larger, N=21), as well as adult male (34.7% larger, N=13) bears during four years of relatively poor food production on the Stratton Mountain Study Area than the home ranges associated with the two years of good food productivity. For both sexes, the largest home ranges were documented during 1992, a year of almost complete soft and hard mast failure (Appendix B). A 6-year old male was monitored that year traveling over an area of 391.5 km^2. Females accompanied by cubs-of-the-year had the smallest home ranges with an average size of 30.02 square kilometers (Table 5.2). Only female #2 deviated from this trend. She produced three cubs during 1990, but still had the largest female home range (Figure 5.1). She may have lost her cubs during that time though, as she was not seen with cubs during the summer and was shot by a hunter in late October. At that time she had no cubs traveling with her.

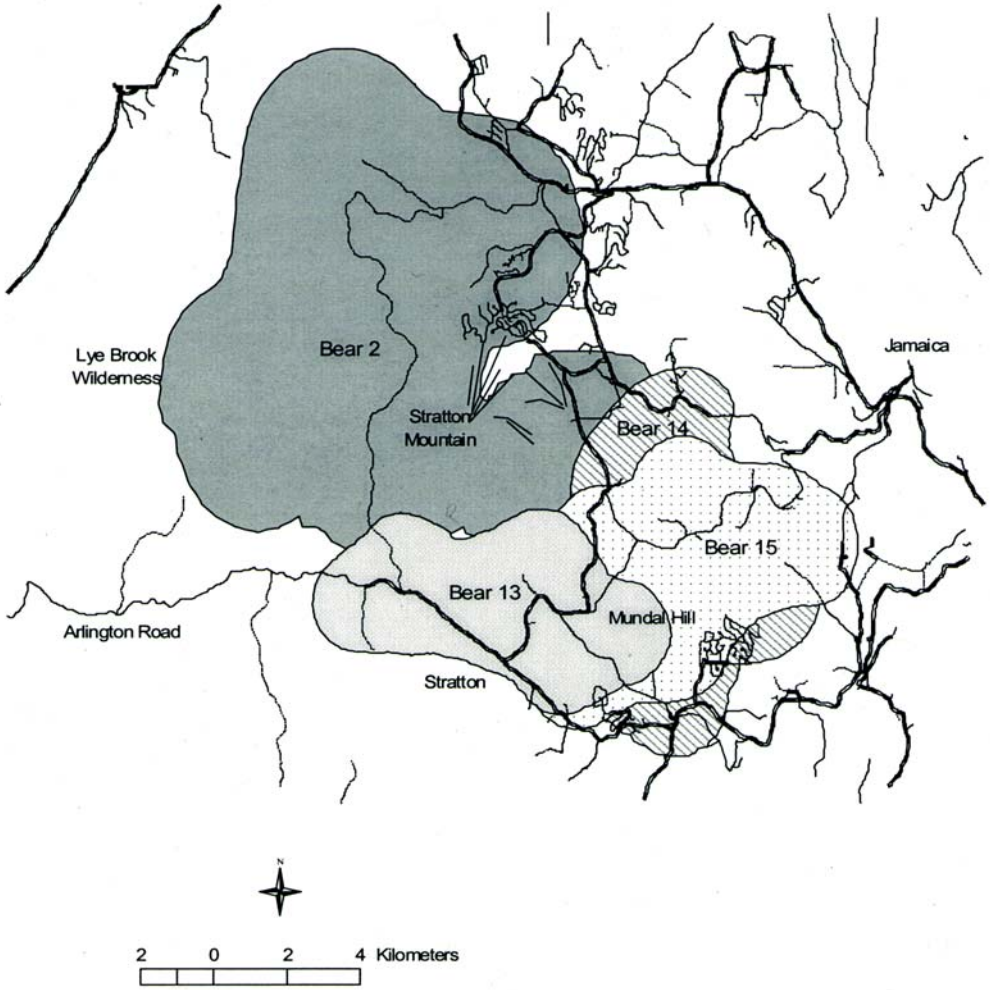

Figure 5.1. Home ranges of female study animals during 1990.

Table 5.2. Annual home range size for females in the year cubs are known to have survived entire year with their mother and for adult females not accompanied by cubs-of-the-year (COY), or where cub fate unknown. Home ranges calculated using Adaptive Kernel (95% contour) method.

Female Status	Number of Ranges	Mean Home Range Size	Range
Accompanied by COY	4	30.02 km^2	17.86-39.01 km^2
Not accompanied by COY or Unknown	16	41.45 km^2	12.42-85.83 km^2

There was considerable home range overlap among female black bears during the six years that they were monitored (Figures 5.1-5.6). The greatest overlap was for yearling female bears within their mother's home range. One used an area of 20.9 km^2 that was completely within her mother's home range while another with a home range of 42.1 km^2 overlapped 81.5% of her sow's range. Subadults continued to use up to 77.1% of their mother's ranges. Subadult #48, as a 3-year old, still used 63.4 km^2 of her sow's home range in 1995 despite concurrent use by a yearling female (#52) whose home range was totally within both her mother's and her older female sibling's home ranges (Figure 5.6). Combined, their home ranges covered an area of 127.0 km^2 during a year when natural foods were in short supply. Two other subadults, during good food years, had much smaller home ranges (86.2 and 34.9 km^2) when combined with their sow's home ranges during years of abundant foods.

Adult female home ranges also overlapped. Female #13, as a small, first-time sow in 1991 shared parts of her home range with three different adult females. Only 18% (8.13 km^2) of her home range was not used by other adult females. This portion of her home range that did not overlap with other collared females was an area bisected by a paved road with houses (Figure 5.2) that she used heavily. Most other adult females had home ranges that were separated by roads. Adjoining adult females seldom crossed roads that bordered their respective home ranges. Both gravel and paved roads were used as home range boundaries. Areas of overlap varied and included wetlands and areas of seasonally concentrated food including apple orchards, a blueberry field, oak stands, beech stands, and areas of abundant jack-in-the-pulpit.

Adult male black bears traveled widely throughout the study area in search of females and food. Their home ranges were significantly larger and usually encompassed several female home ranges (Figure 5.7). They did not appear to have a defined pattern of travel and often several would occupy the same area where there were concentrated foods or where a female was believed to be in estrous.

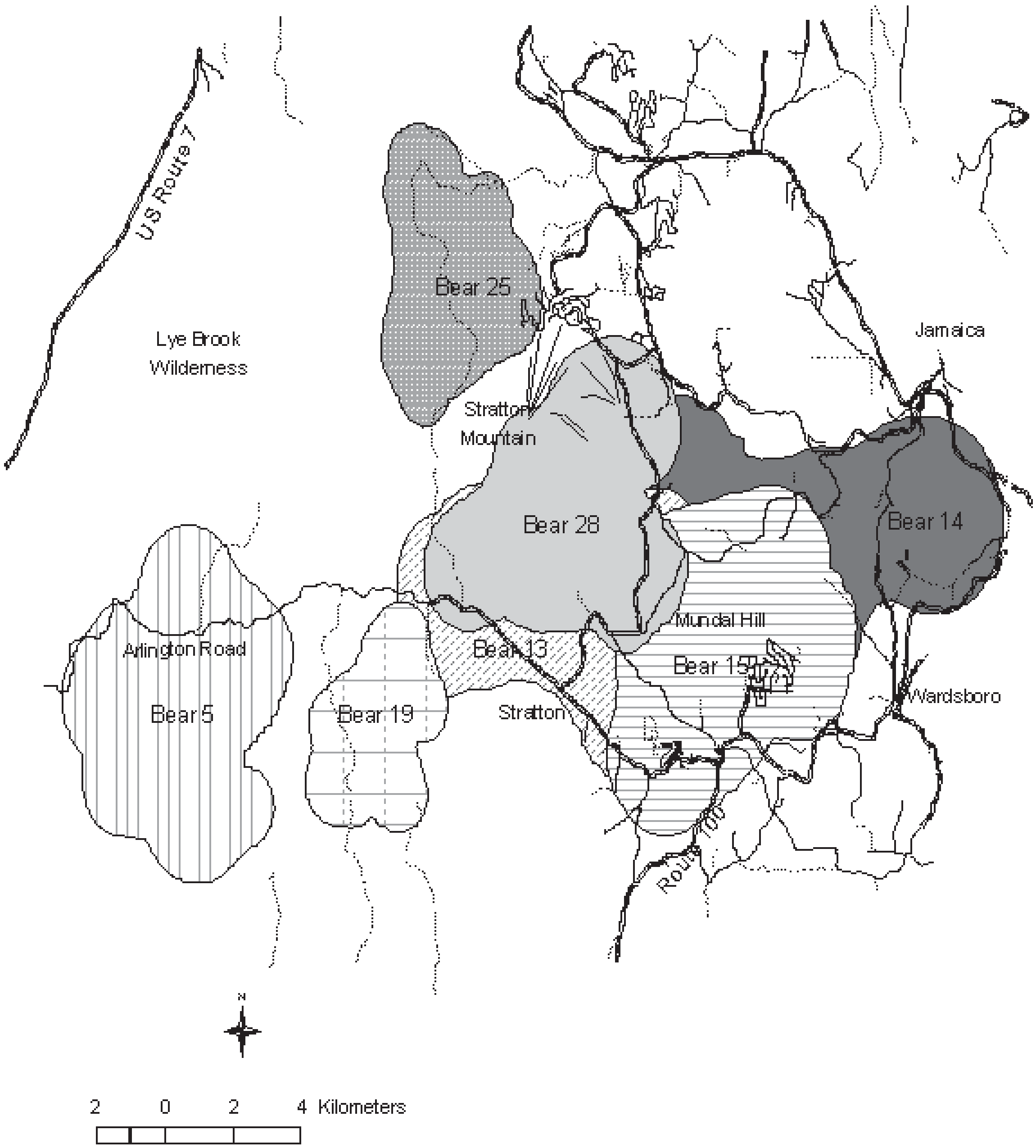

Figure 5.2. Home ranges of female study animals during 1991. Soft and hard mast was extremely plentiful throughout the Study Area.

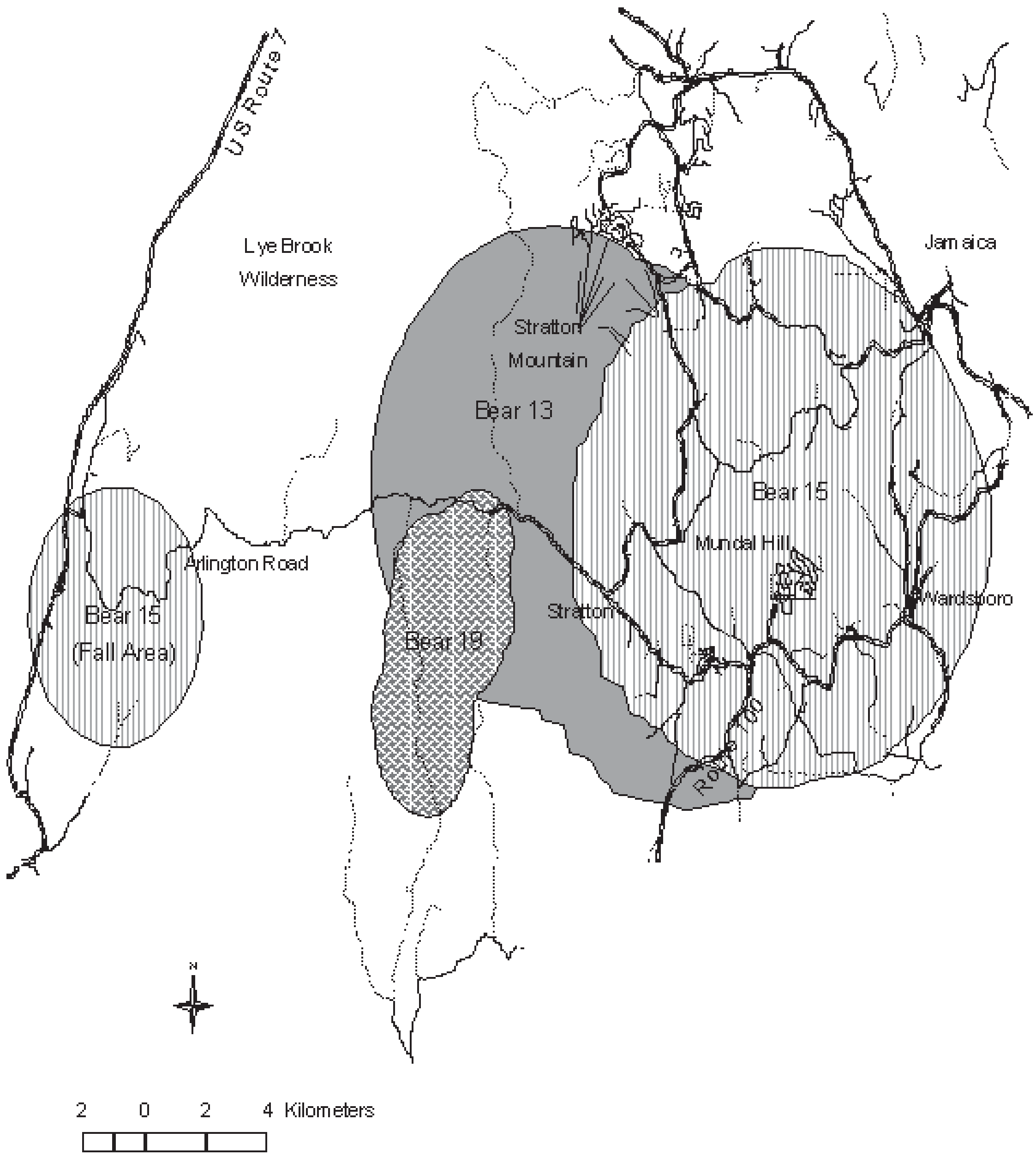

Figure 5.3. Home ranges of female study animals during 1992. Both hard and soft mast were almost absent over most of the Study Area causing many animals to travel widely.

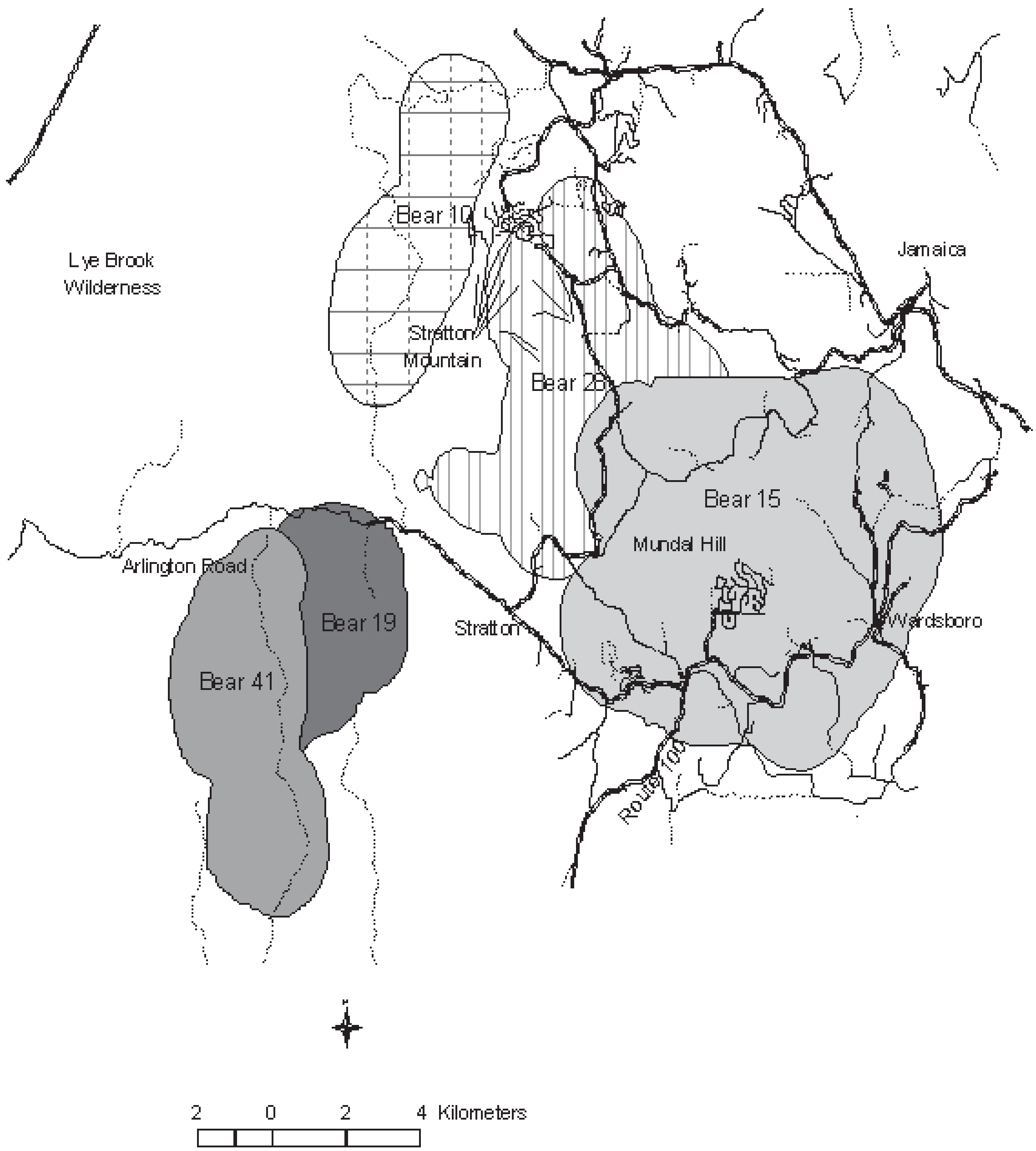

Figure 5.4. Home ranges of female study animals during 1993.

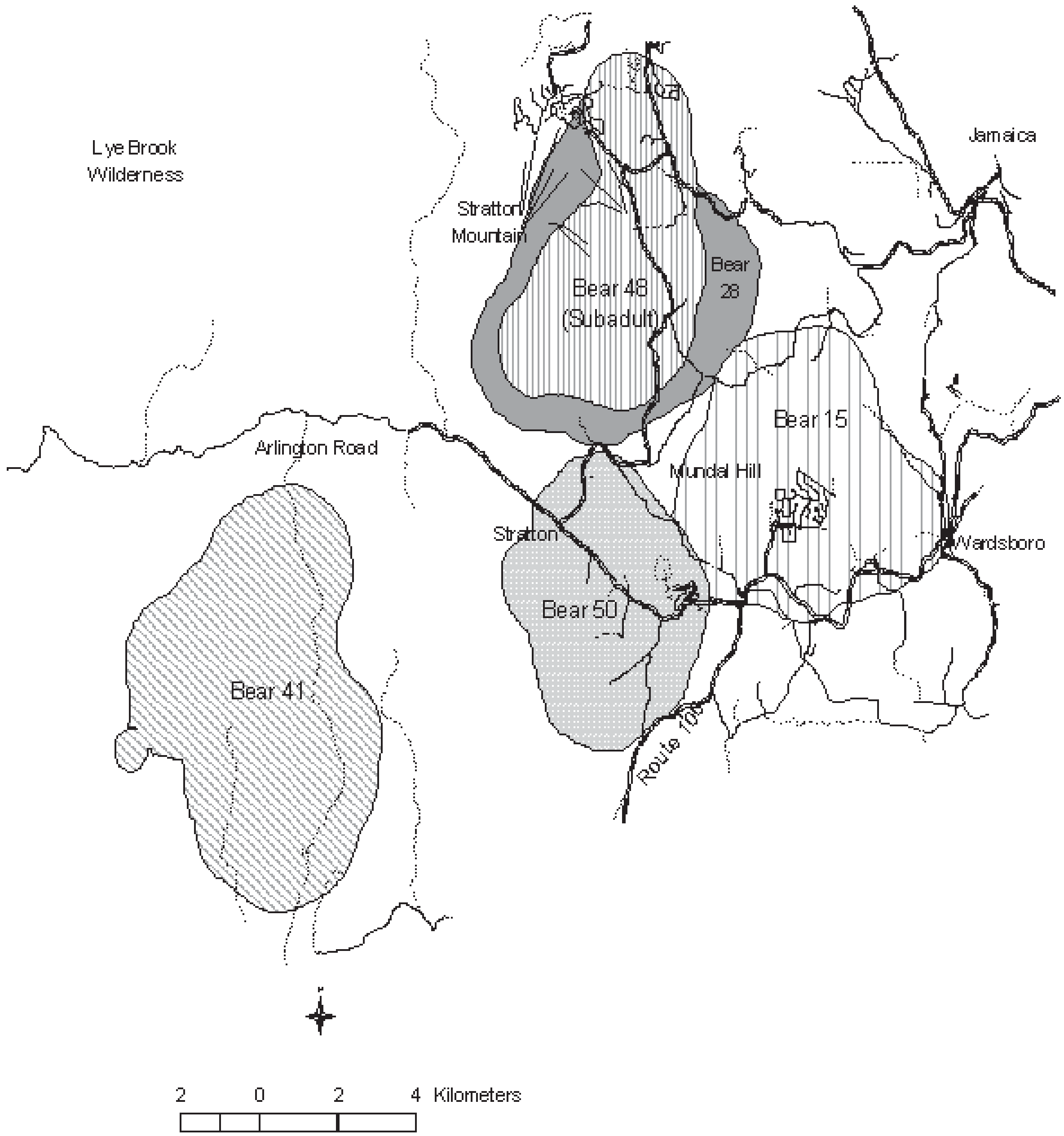

Figure 5.5. Home ranges of female study animals during 1994.

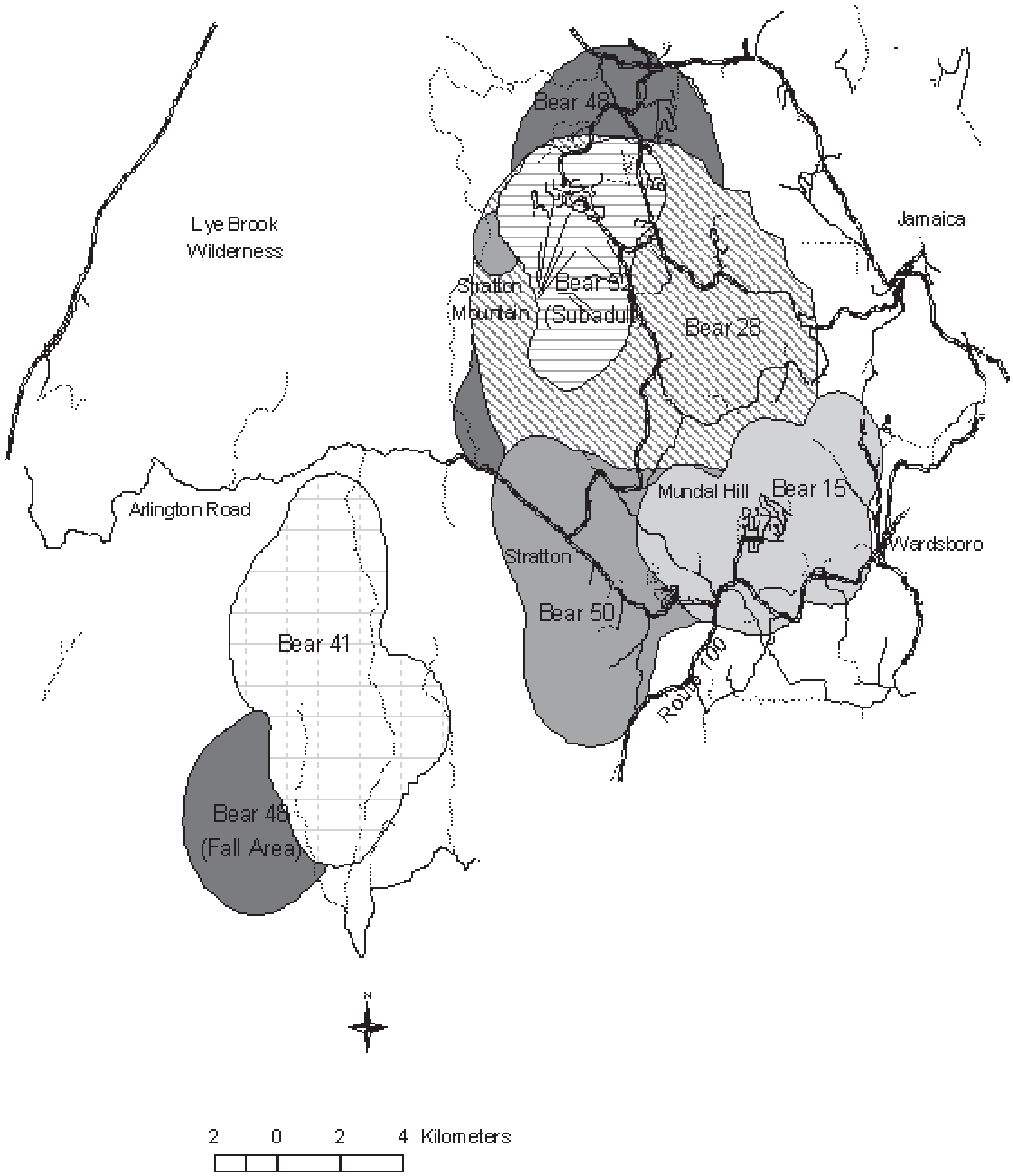

Figure 5.6. Home ranges of female study animals during 1995.

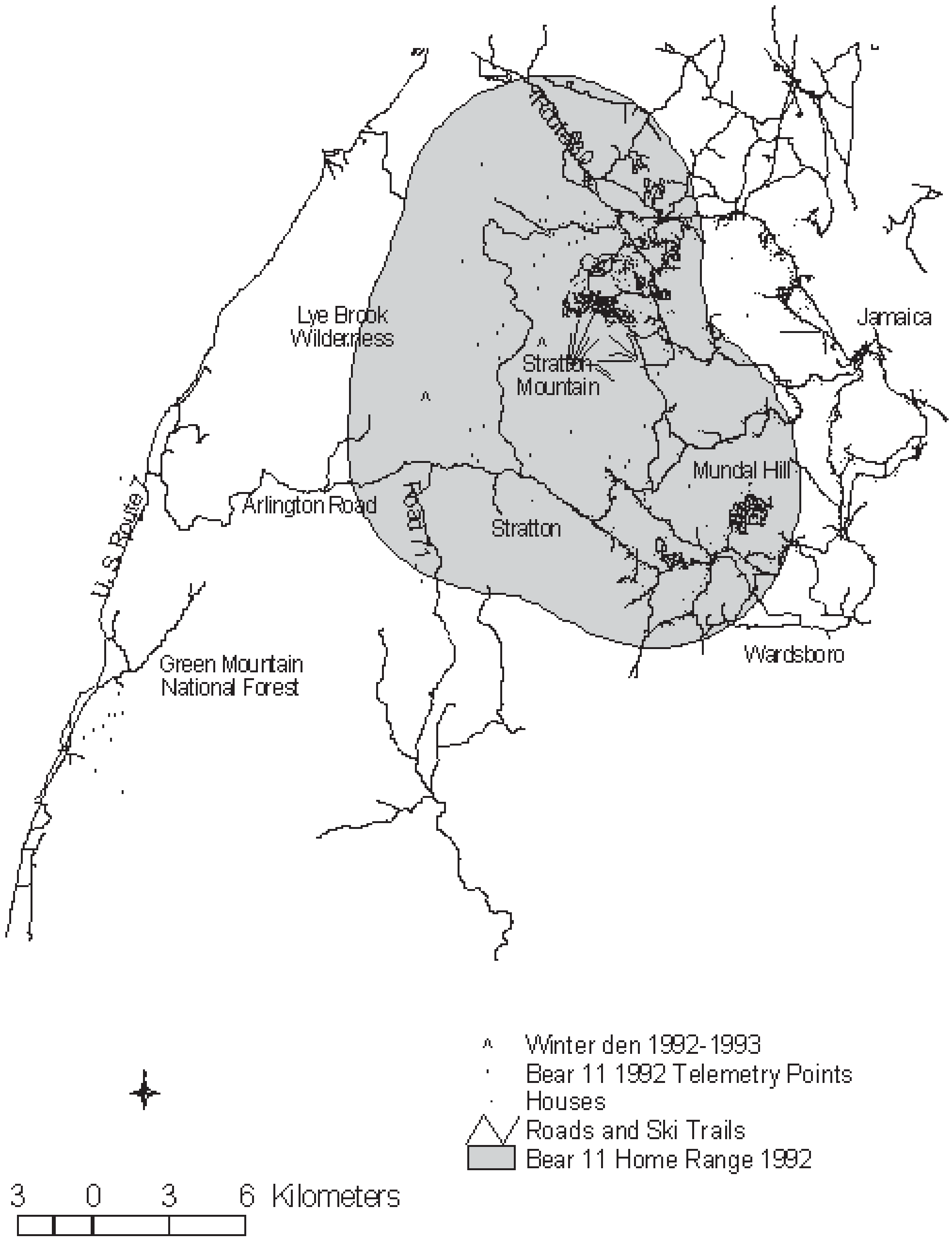

Figure 5.7. Home range (95% contour) of adult male Number 11 during 1992 with telemetry locations, houses, and roads. Locations closest to Route 7 were during the fall season.

Seasonal and Elevational Movements

Subadult and adult male black bears traveled widely during each year that they were monitored while females were observed to stay primarily within their home ranges during years when late summer and fall mast was available. It was only during the severe food shortage years of 1992 and 1995 that females also took extended sallies beyond their normal ranges. During these two years, most females abandoned their home ranges in late summer and moved an average of 14.5 kilometers away to find food. The farthest straight line distance traveled was by a 14-year old female that traveled at least 27.5 kilometers (Table 5.3) from her normal range on Stratton Mountain east to a commercial apple orchard near Interstate 91 in the town of Westminster. Several other females undertook similar peregrinations to the west where they stopped alongside of Route 7 in the towns of Sunderland and Shaftsbury without crossing the highway, and foraged in areas of black cherry and red oak stands that had some mast available. Most females traveled west of Stratton Mountain during food shortage years in a direction unimpeded by major highways until reaching Route 7. No females traveled north outside of the main study area, a direction that would have involved crossing two major highways. Most males were not impeded by highways and traveled widely, especially in the summer and fall seasons in search of concentrations of natural foods and fields of feed corn. The farthest straight line distances traveled by a male bear was for a 2-year old collared in Massachusetts that was located 35 kilometers north of the state border in the Bourne Pond area of the Lye Brook Wilderness Area. Major highways such as Routes 7, 9 and 11 did not appear to act as barriers to the movements of most male bears. Crossing these highways allowed them access to corn and to an abundance of wild foods that grew along the edges of cornfields such as grapes, chokecherries, and elderberries that were unavailable to females and other bears remaining in the Study Area.

Study animals were generally found at lowest elevations during summer months and at highest elevations during the fall (Table 5.4). During the summer months and some spring seasons most black bears were at low elevations feeding on green vegetation, most notably one species of sedge *(Carex gynandra)*, jewelweed *(Impatiens biflora)*, and jack-in-the-pulpit *(Arisaema triphyllum)*. Bears were not at low elevations during spring, especially in years following good beech nut production when they foraged on germinating beech nuts in remote beech stands until early June.

Table 5.3. Farthest distance traveled by black bears outside of their home ranges each year. Stratton Mountain Black Bear Study, 1990-1995.

Females				Males			
Bear ID	**Year**	**Bear Age**	**Distance (km)**	**Bear ID**	**Year**	**Bear Age**	**Distance (km)**
2	1990	10	12.3	9	1991	10	12.5
5	1991	4	5.0	9	1994	13	8.6
10	1993	4	6.1	11	1990	4	12.7
13[a]	1990	3	6.9	11	1991	5	15.6
13	1991	4	6.8	11	1992	6	26.8
13	1992	5	25.8	11	1994	8	16.0
14[a]	1990	1	8.4	12	1991	9	18.4
14[a]	1991	2	7.4	16	1991	11	14.2
15	1990	6	8.0	16	1994	14	9.5
15	1991	7	10.3	21	1991	6	14.6
15	1992	8	25.9	22[a]	1992	3	27.1
15	1993	9	11.9	23	1991	6	10.7
15	1994	10	7.8	26[a]	1991	1	5.1
15	1995	11	5.9	27	1992	4	8.2
19	1991	11	5.0	32[a]	1992	2	14.8
19	1992	12	5.0	42[a]	1993	2	3.6
19	1993	13	4.3	43	1993	5	28.9
25	1991	4	4.0	43	1994	6	11.7
28	1991	10	5.2	51[a]	1994	1	5.4
28	1993	12	4.5				
28	1994	13	8.0				
28	1995	14	27.5				
41	1993	15	5.6				
41	1994	16	5.4				
41	1995	17	7.1				
48[a]	1994	2	5.9				
48[a]	1995	3	13.2				
50	1994	8	4.6				
50	1995	9	5.7				
52[a]	1995	1	4.2				

[a] *Subadult <4 years old*

Table 5.4. Mean elevation of telemetry locations of adult and female black bears by season in the Stratton Mountain Study Area of Vermont, 1990-1995.

Season	Number of Locations	Mean Elevation (meters) Adult Females	Adult Males	All Bears
Spring	627	626	625	626
Summer	1708	607	626	607
Fall	820	650	676	660

Foods and Food Availability

Black bears ate a wide variety of food items during the six years studied, but relatively few were ever available at any given time in a large enough quantity to be of major importance. Researchers throughout this study examined scats and feeding sites to compile a list of plant and animal species eaten by black bears within the Study Area (Appendix C). Only three species were consistently available and consumed in large amounts each year (photos in Figure 5.8) during the spring and summer periods.

Tall nodding sedge *(Carex gynandra)* was found throughout the study area in disturbed, wet sites and constituted a large part of the early spring diet each year. It was found primarily on old logging roads, log "skidder" trails, log landings, in shaded portions of ski trails, on the dams, and around the edges of some beaver ponds. Although growing to heights of four feet or more, we observed it being selected only in its early growth form when under eight inches in height.

Jewelweed was eaten throughout late spring, summer, and early fall. Its succulent leaves and stems made up a large part of the diet, especially in dry years when other succulent vegetation was scarce. It too was found on wet sites disturbed by logging, trails, roadsides, and on some beaver dams. Jewelweed was most concentrated on treated wastewater sprayfields. Each of the mountain resorts surrounding Stratton Mountain had sprayfields with abundant jewelweed, but black bear use varied due to sprayfield location and management which in turn affected the quantity of succulent plants and an individual animal's willingness to tolerate foraging in proximity to human activity.

Jack-in-the-pulpit appeared to be the food item most utilized by bears in all years. Its root, or "corm", was sought after during the spring, summer, and fall, even during years when other favored foods were plentiful. The corm can be large and has a food value that approximates that of beech nuts and acorns (Table 5.5), and is available during time periods when nuts and berries are not. It occurs in moist, mature hardwood understories at lower elevations in areas of deep soils and is often found in concentrations near roads and residential developments where the soils and soil hydrology has been altered.

Figure 5.8. Photographs of three plant species as food for black bears in southern Vermont; tall nodding sedge, *Carex gynandra* (at top); jewelweed, *Impatiens biflora* (center); and jack-in-the-pulpit, *Arisaema triphyllum* (bottom).

Table 5.5. Gross energy, crude protein, and metabolicable energy values for three important black bear foods.

Food Item	Crude Protein %	Gross Energy (Kcal/g)	Metabolicable Energy (Kcal/g)
Acorns[a]	8.0	4.5	2.8
Beechnuts[a]	15.3	5.5	2.7
Jack-in-the-Pulpit[b] corms	14.3	3.7	3.2

[a] *Servello and Kirkpatrick, 1987.*
[b] *Collected in Vermont and analyzed at the UMASS Food Sciences Lab in 1995 for this study.*

Researchers in 1994 documented the largest concentrations of jack-in-the-pulpit (JIP) and jewelweed growing on the north and east sides of Stratton Mountain, especially near residential developments adjacent to Braziers Way and Birch Hill and along the Winhall River (Table 5.6).

The greatest concentration of these plants were found in a 42-acre tract used by the Stratton Resort as a treated wastewater sprayfield. Telemetry revealed that several female bears, including one with cubs, used the artificial wetland each summer. During June, feeding was heaviest on young jewelweed plants, but during July and August most feeding was on jack-in-the-pulpit. The vegetation was so lush within the sprayfield that the travel routes of each bear could be easily tracked by following the trails of crushed plants. In this manner, we documented one bear digging 88 jack-in-the-pulpit corms, and another that dug 60, within a distance of only 100 meters.

Major late summer and fall foods that were available in some years and highly sought after by bears when available included beech nuts, red oak acorns, apples, black and choke cherries, blackberries, raspberries, mountain ash berries, blueberries, and shad berries. Mast-producing beech trees were common on the Study Area while red oak occurred primarily at lower elevations on the eastern border of the Study Area and in greater amounts east and west of the Study Area. Unfortunately, each of these species was extremely variable in terms of availability year to year (Table 5.7). Beech nuts and blueberries were available in only two of six years while quantities of mountain ash berries were available in only one year. The most consistent fall food for some male bears was corn, but this only occurred outside the Study Area and was not utilized by females.

Table 5.6. Occurrence of select spring and summer bear food species on Stratton Mountain, Vermont in 1994 using point intercept transects.

Area	Percent Occurrence: Jack-in-the-Pulpit (%)	Jewelweed (%)	Sedge (*C. gynandra*) (%)	Transect Length (paces)
N. side of Stratton Mtn.	2.1	3.3	0.4	4,300
E. side of Stratton Mtn.	0.6	6.9	0.2	7,000
S. side of Stratton Mtn.	0.1	0.0	0.0	7,075
W. side of Stratton Mtn.	0.1	0.0	0.0	5,000
Braziers Way	7.4	5.2	0.2	5,250
Birch Hill/Winhall River	3.4	2.5	2.2	7,645
Thinned	1.0	0.0	0.0	2,100
Unthinned	11.6	0.8	0.0	3,030
Old Spray Area	20.0	76.2	0.0	2,642

[a] *Trees thinned in 1993 prior to laying spray pipe and still under construction in 1994.*

Powerlines running across National Forest lands were a major source of raspberries to many study animals, but in some years these areas were treated with herbicides before the berries could be utilized. Blueberries were not plentiful in the Study Area although they were found in some clearcut areas. The greatest concentration of blueberries was within the Grout Pond Controlled Burn Area on the National Forest. This area attracted large numbers of black bears during the late summer and early fall time periods when blueberries were available, including females with cubs and at least eight study animals.

During the late summer and early fall, study animals were attracted to logging roads and areas where timber had been harvested within the past 15 years that produced large amounts of blackberries. Even during years of poor soft mast production, bears utilized these areas to obtain insects from rotten logs and stumps.

Table 5.7. Availability of major black bear food species in southern Vermont, 1990-1995. Beech nut and acorn availability was based on plot data collected as part of the Vermont Fish and Wildlife Department mast survey while other species were by ocular estimates.

Year	Beech	Oak	Cherries	Apples	Black-berries	Rasp-berries	Mtn. Ash	Blue-berries	Shad-berries	Overall Rating
1990	Poor	Fair	Excellent	Poor	Poor	Poor	Poor	Poor	Poor	Fair
1991	Excellent	Excellent	Good	Excellent	Excellent	Good	Poor	Fair	Fair	Excellent
1992	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Fair	Poor
1993	Poor	Excellent	Fair	Good	Fair	Fair	Poor	Poor	Fair	Fair
1994	Good	Fair	Excellent	Fair	Fair	Fair	Excellent	Good	Good	Good
1995	Poor	Poor	Poor	Fair	Fair	Fair	Poor	Poor	Poor	Poor

Two plant species, skunk cabbage *(Sympolocarpus foedidus)* and squaw root *(Conopholis americana)*, have been reported as extremely important bear foods in other areas of the eastern United States but were not documented within the Study Area. Reports of skunk cabbage were common but most turned out to be false hellebore, an early spring forb that grows in similar habitats but is not eaten by black bears. Because these two plants (Figure 5.9) are known to be important black bear foods in other areas of the eastern United States, biologists should continue to record their locations within Vermont.

Use of Wetlands

The use of wetlands by black bears was investigated by University of Vermont graduate student Betsy Glenn during 1991 and 1992 within the Stratton Mountain Study Area. She used 1010 telemetry locations of six females and eight male radio-collared bears to determine habitat preference and level of use of wetlands (Glenn 1993). For both years combined, 12 of the 14 bears used wetland and upland habitat in proportion to availability on a year-round basis. Neither of the two bears that used habitat disproportionately showed selection ($P<0.10$) for wetland and upland habitat. Only three female bears had adequate sample sizes to examine habitat use in each year separately. One female with cubs-of-the-year (female No. 15 in 1991) showed selection for wetland habitat. Other females used habitat in proportion to availability. Results from her study suggest that all wetlands, especially forested ones, are not used uniformally by black bears. She also noted that there were differences in the amount of use of wetlands during the two years of her investigation and speculated that the availability of beech nuts during the spring of 1992, as well as limitations in telemetry accuracy, may have affected her results. She noted more reuse of wetlands by females than by males. Her results from site visits and the analysis of vegetative and non-vegetative wetland data indicated that relatively small (3ha) wetland complexes and riverine wetlands with stream widths of 3-6m were used most often by black bears, but that radio telemetry was not accurate enough to determine use versus availability of such small areas. She also noted variable use of wetlands between different bears and seasons and suggested that wetland habitat may be more important for providing for other bear needs than just gaining food. She noted use for cooling, escape cover, and as selected areas for crossing roads and highways.

Using pooled telemetry data from 1990-1995 (N=3155 locations), and site location checks in the field, we determined that black bears did not select for streams or Class 1 and 2 wetlands in the Stratton Mountain Study Area. According to the Vermont Wetland Rules, wetlands in the state are classified as Class 1, Class 2, or Class 3. Highest use was observed for the summer period (Table 5.8) rather than the spring period as reported elsewhere for study areas where skunk cabbage are common. Wetlands and streams were used as crossing areas of paved roads, perhaps due to these areas providing more dense concealment cover.

Figure 5.9. Two plant species reported as extremely important black bear foods in other areas of the eastern United States, but which were not found within the Stratton Study Area. Status and distribution unknown in Vermont. Squaw root, *Conopholis americana* (top) and skunk cabbage, *Sympolocarpus foedius* (bottom).

Table 5.8. Seasonal comparison of bear telemetry locations within 200 meters of hydrological features including streams, class I and II wetlands. Stratton Mountain Study Area, 1990-1995.

		Within 200 m of Streams and Class I and II Wetlands	
Season	**Total N**	**Number of Locations**	**Percent**
Spring	627	89	14.19
Summer	1708	318	18.62
Fall	820	114	13.90
	3155	**521**	

Use of Beech and Oak Stands

Production of hard mast, both from beech and red oak, was highly variable from 1990-1995 (Table 5.7). Beech nuts were available in only two of six years while acorns were available as a major food item in four of six years. In the two fall seasons, 1991 and 1994, that beech nuts were available, they were fed on heavily by black bears resulting in heavier body weights, smaller home range sizes, and fewer long distance forays outside of home ranges. During these years of beech mast abundance black bears selected beech stands at higher elevations and further from roads than in other years when beech nuts were scarce (Table 5.9). Beech nuts were also available in the spring seasons following years of high beech nut production. During these years bears fed on the germinating seeds through the end of May at higher elevations and further from roads than in other spring seasons (Table 5.9). Beech stands receiving high use were all remote from roads and buildings. We examined 42 beech stands state-wide and documented that for the 26 stands showing the most use, the mean distance to roads or buildings was 2.1 km and that only 2 were less than 0.8 km from areas of human activity (Table 5.10). Areas within beech stands that showed the greatest amounts of use (determined by bark scarring, Wolfson and Hammond 1992) contained thick understory cover, numerous boulders or ledges, and were in areas of broken terrain that provided concealment cover for bears while feeding.

Acorns from red oaks were more consistent in their availability annually than beech nuts, but were not selected by black bears to the extent that beech nuts were. The greatest use of acorns was observed in 1993 when beech nuts were scarce while acorns were plentiful. Oak was not a major forest component of the Study Area though, and most acorns were consumed by wildlife prior to the following spring season. Using telemetry locations and mast abundance observations we documented that acorns were not a major spring food of black bears. Exceptions to this were noted once following an autumn of extremely high nut production. We observed that acorns fall earlier than other hard mast and that they are usually consumed by wildlife prior to the first heavy snow cover. Beech nuts fall later in the season and were available to the bears in the spring season as well. Most oak stands were located on the eastern edge of the Study Area on private lands east of Stratton Mountain at lower elevations (Figure 5.10).

Table 5.9. Effects of beech mast production on fall bear locations in relation to distance from roads and elevation.

Fall Mast Availability	Distance to Roads (meters)					
	All Bears			Adult Females		
	N	Mean	SD	N	Mean	SD
Good to Excellent**	399	896	665	173	980	682
Poor to Fair**	478	808	840	414	834	1118

Fall Mast Availability	Elevation (meters)					
	All Bears			Adult Females		
	N	Mean	SD	N	Mean	SD
Good to Excellent**	366	713	128	161	714	142
Poor to Fair**	454	631	163	392	658	148

** Pooled fall location data for 1991 and 1994.*
*** Pooled data for 1990, 1992, 1993, and 1995.*

Table 5.10. Inventory of 42 bear-clawed beech stands sampled in Vermont in 1991 and 1994. Shown is the location, level of black bear use, distance to human impacts, overall stand size, and WMU* within which the stand is found.

WMU	Stand #	Stand Name	Topographical Map	Town	Bear Use Fidelity Rating	Distance to Human Impacts (miles)	Stand Size (acres)
L	15	Russell Hill	Killington Peak	Shrewsbury	0	0.06	40
P	35	USFS Comp. 148, St. 21	Stamford	Stamford	0.5	0.3	63
L	27	USFS Comp. 59, St. 15	Peru	Dorset	0.7	0.2	45
O_1	7	Weston	Weston	Weston	0.9	0.5	49
L	17	Rutland City Forest	Killington Peak	Mendon	2.4	0.63	155
M_1	22	South Morgan Peak	Plymouth	Plymouth	4.6	0.63	79
G	24	Smuggler's Notch	Mt. Mansfield	Cambridge	5.1	0.1	117
L	14	Saddle Mtn.	Killington Peak	Shrewsbury	5.9	1.0	170
L	13	Smith Peak	Killington Peak	Shrewsbury	7.1	0.75	115
L	32	USFS Comp. 58, St. 10	Danby	Peru	7.7	1.0	64
G	40	Bolton	Bolton	Bolton	7.7	0.3	44
L	16	Robinson Hill	Killington Peak	Mendon	8.9	2.25	218
P	21	Kidder Brook South/USFS	Stratton Mtn.	Stratton	9.0	1.0	114
L	5	Ingalls Hill	Killington Peak	Shrewsbury	9.1	0.13	20
P	20	Kidder Brook North	Stratton Mtn.	Stratton	9.5	1.00	75
P	33	USFS Comp. 144, St. 2	Sunderland	Sunderland	9.8	0.6	70

Continued...

Table 5.10. *(Continued)*

WMU	Stand #	Stand Name	Topographical Map	Town	Bear Use Fidelity Rating	Distance to Human Impacts (miles)	Stand Size (acres)
E	10	Bull Mtn. East	Burke	Ferdinand	11.1	4.13	12
P	37	Readsboro (Windtower Area)	Readsboro	Searsburg	11.7	0.5	175
P	39	USFS Lamb Brook (Comp. 124, St. 55)	Readsboro	Readsboro	11.8	1.4	44
L	4	Saltash Mtn.	Mt. Holly	Plymouth	12.4	1.75	395
L	3	Burnt Mtn.	Killington Peak	Plymouth	12.5	0.9	80
L	12	Plymsbury WMA #1	Killington Peak	Shrewsbury	12.5	0.63	30
P	18	Spray Field (Stratton)	Peru	Winhall	12.5	.25	22
L	6	Sisters (Coolidge)	Killington	Plymouth	14.4	1.75	50
L	2	Jockey Hill	Killington	Shrewsbury	18.1	1.3	187
G	42	Sugarbush	Mt. Ellen	Fayston/Warren	18.2	1.0	846
P	29	USFS Lamb Brook (Comp. 124, St. 60)	Readsboro	Readsboro	20.1	2.5	31
L	25	Colgan Land	Killington Peak	Shrewsbury	21.0	1.5	30
P	28	USFS Lamb Brook (Comp. 124, St. 57/8)	Readsboro	Readsboro	21.5	2.25	37
J_1	36	Mahon Bethel	Randolph	Rochester/Bethel	25.4	0.5	41
P	19	Kidder Brook South/Private	Stratton Mtn.	Stratton	25.6	0.75	38
P	38	USFS Lamb Brook (Comp. 124, St. 49)	Readsboro	Readsboro	28.0	1.3	46
L	1	Parker’s Gore	Killington Peak	Mendon	28.6	.5	250

Continued...

Table 5.10. *(Continued)*

WMU	Stand #	Stand Name	Topographical Map	Town	Bear Use Fidelity Rating	Distance to Human Impacts (miles)	Stand Size (acres)
G	31	Burt Ranch/Mansfield	Mt. Mansfield	Stowe/Underhill	28.9	2.3	102
C	8	Jay Peak	Jay Peak	Jay	29.8	.38	96
P	34	USFS Comp. 148, St. 19	Stamford	Stamford	32.1	0.9	29
P	26	Mt. Snow/Haystack	Mt. Snow	Dover	32.5	0.5	175
H_1	30	Mt. Hunger #1	Stowe	Worcester	37.8	1.0	112
L	23	Okemo State Forest	Mt. Holly	Mt. Holly	46.0	1.0	86
H_1	41	Mt. Hunter #2	Stowe	Worcester	49.0	1.0	18
P	11	Wainrib	Stratton Mtn.	Stratton	50.5	.75	50
E	9	Bull Mtn.	Burke Mtn.	Ferdinand	52.3	3.13	9

* **WMU** - Wildlife Management Unit

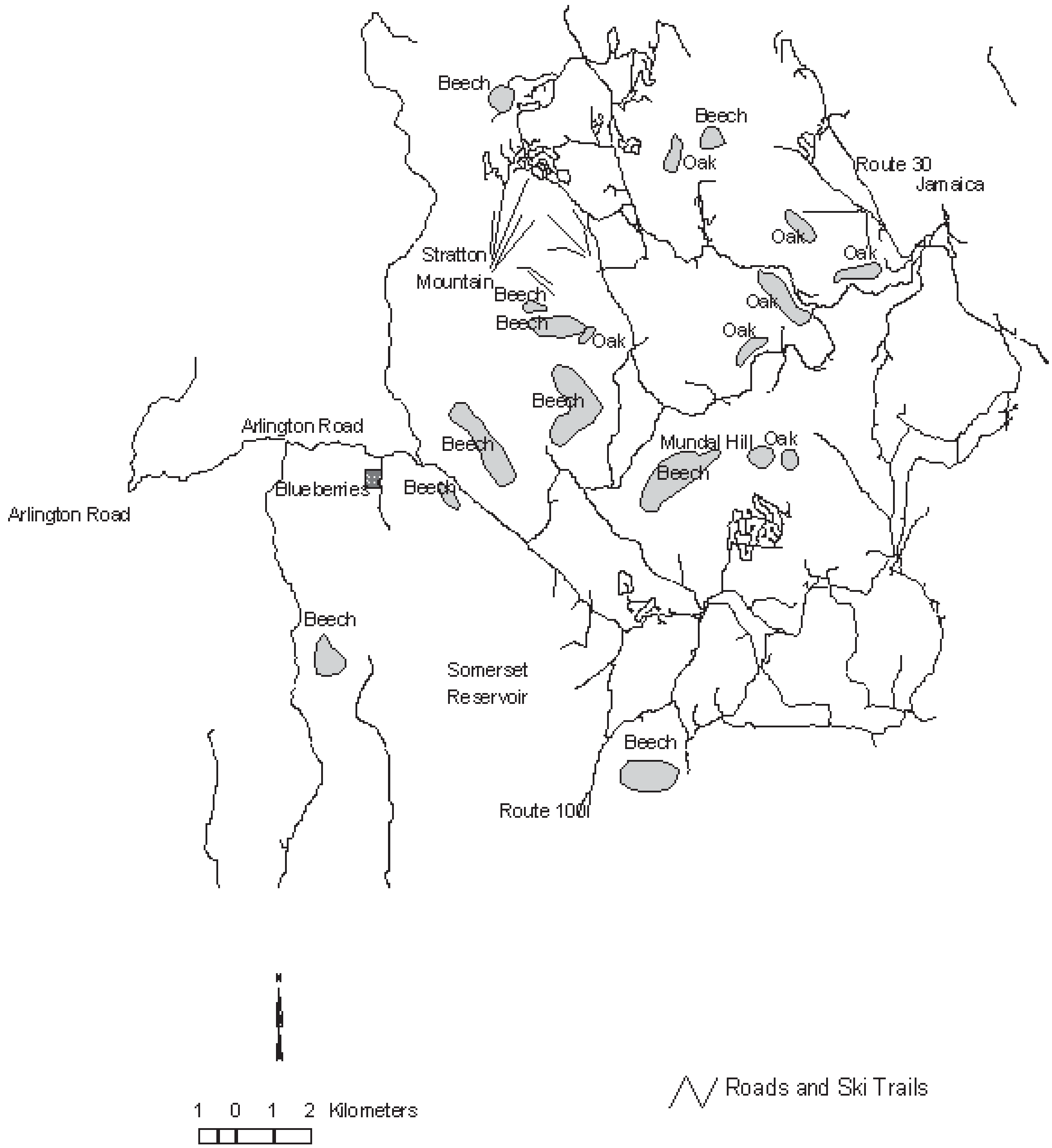

Figure 5.10. Locations of beech and oak stands in the Stratton Black Bear Study Area of southern Vermont. One important source of blueberries is also shown.

Ecological Land Types

We examined black bear preference and avoidance of 843 km^2 of the Study Area that had been mapped and classified by the U.S. Forest Service into 45 different ecological types having different biological and physical features. These units were identified through soils and vegetative tendencies and are intended to aid in long-range planning on the southern half of the Green Mountain Forest (Mitchell 1988). Coverage was available for only the central and westernmost portions of the Study Area (Figure 5.11).

The difference between the rank of use and rank of availability of the 45 ELT's was evaluated using 2,343 of the telemetry location points in the classified area. Chi-square analysis revealed 20 ELT's (44%), representing 36 percent of the mapped area, were used out of proportion to availability ($P<0.05$). Simultaneous confidence intervals, using the Bonferronzi Z statistic, indicated 8 were used more than expected and 12 less than expected (Table 5.11). ELT 612a had the highest use and occurred only in the Kidder Brook and Stratton Mountain Resort region of the Study Area (Figure 5.12). ELT 405b was also selected by black bears during all seasons and was a common habitat type throughout the Study Area. The eight ELTs favored by black bears had the common characteristics of being hardwood sites with wetter, poorly-drained soils than most other ELT's. They also tended to have a higher species richness in tree and ground flora species, including containing the important food plant jack-in-the-pulpit.

Den Characteristics

Fifty-nine black bear den sites were visited during the winter months of 1989-96 on the Stratton Mountain Black Bear Study Area (Figure 5.13). An additional three dens were recorded from second denning attempts after the first was abandoned. Bears selected dens beneath the trunks of windblown conifer trees (N=14), under slash piles (N=13), dug within the root systems of trees (N=12), in large hollow logs (N=8), in rock crevices (N=6), in hollow standing trees (N=5), and within stands of dense spruce trees on piles of green branch tips that resembled large goose nests (N=4). Twenty dens were located within or under the trunks of trees that were greater than 24 inches dbh (diameter at breast height) including two that had been left as wildlife trees ("snags") within clearcuts and two others that had been girdled by chainsaw cuts and left standing in areas of selective tree harvest.

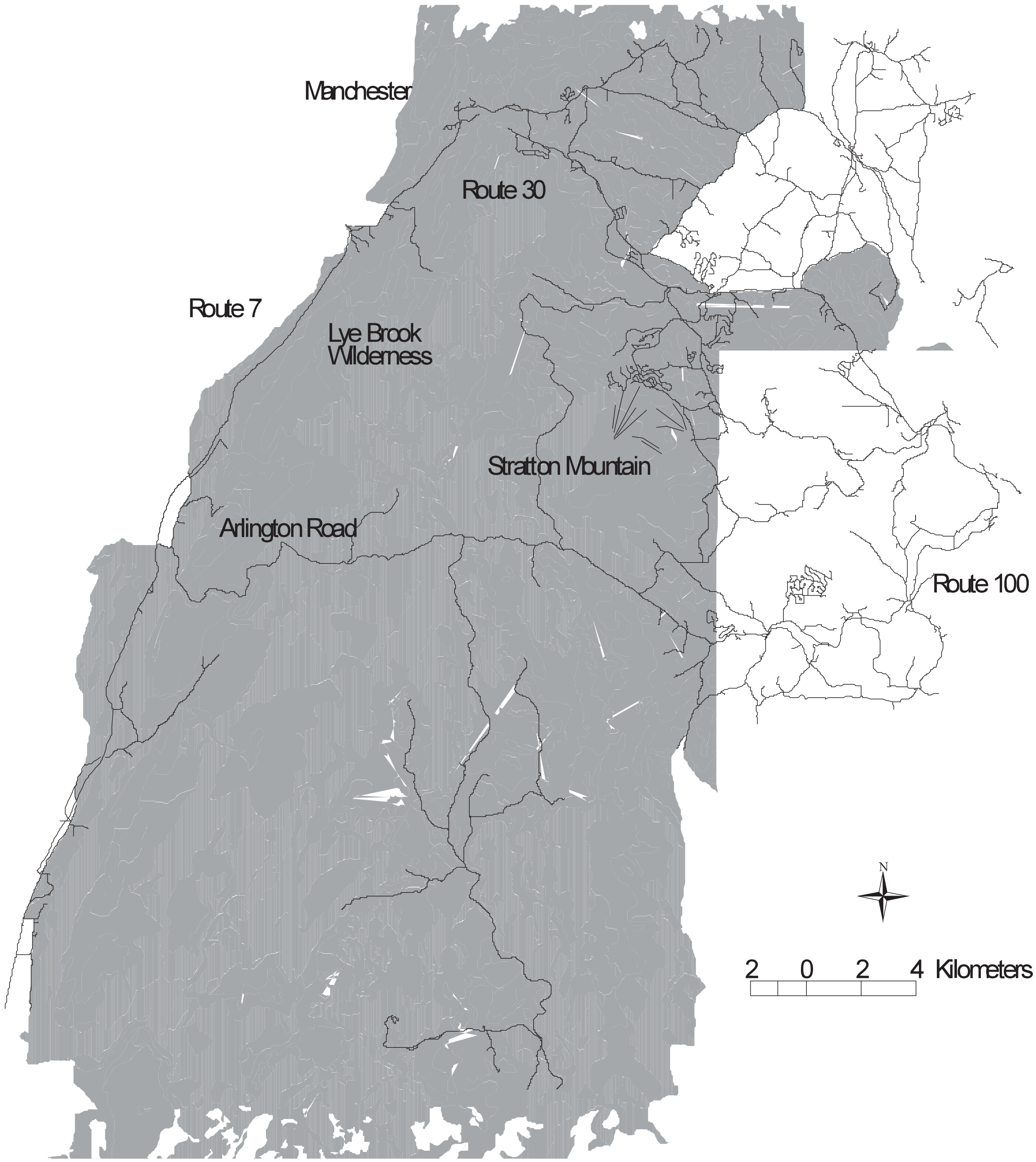

Figure 5.11. Ecological Land Type Classification coverage for the Stratton Mountain Study Area. Coverage was for only part of the Study Area, primarily on lands owned by the Forest Service and some adjacent private lands, most notably the Stratton Mountain Resort.

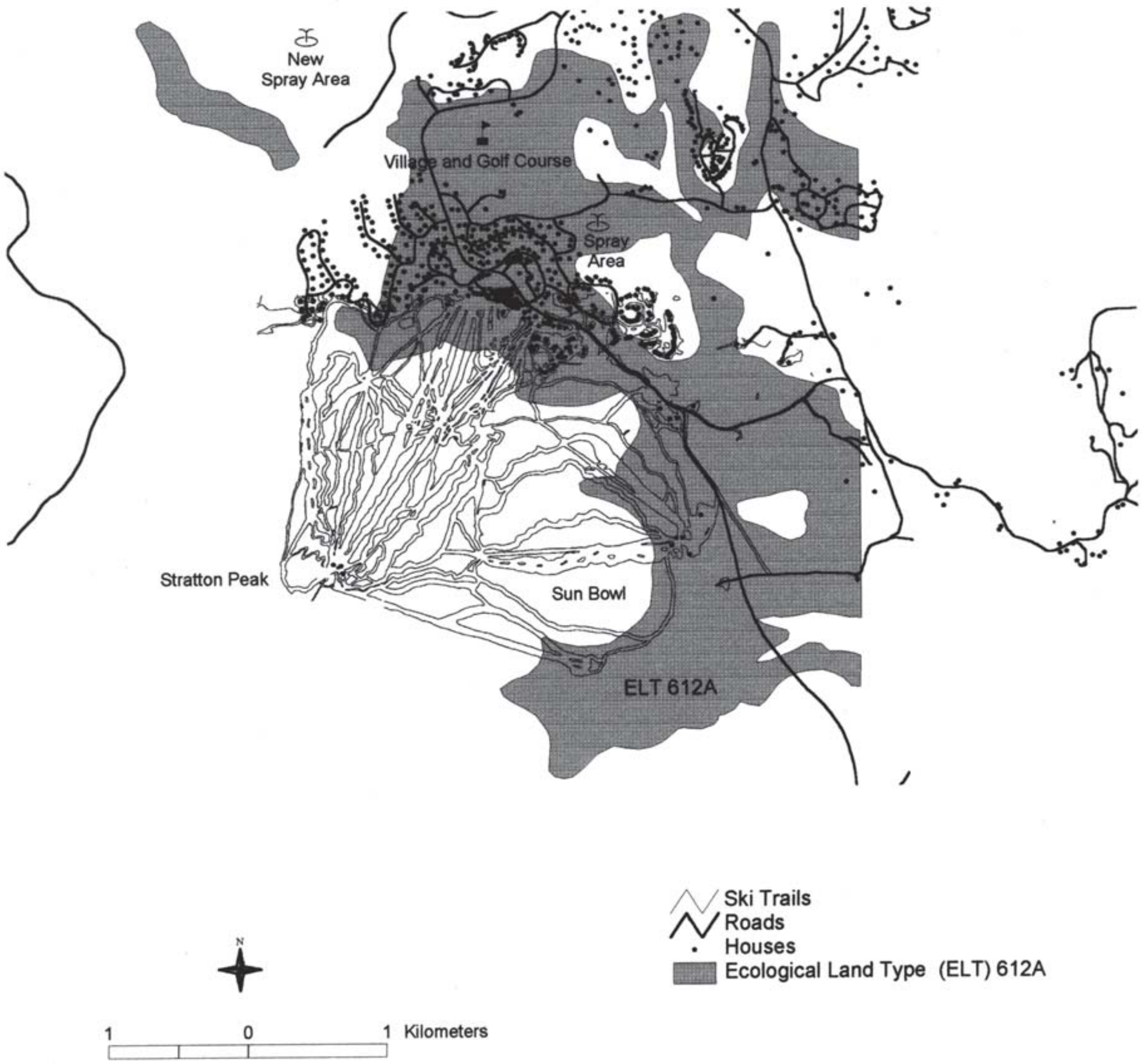

Figure 5.12 Ecological Land Type 612A (*shaded*) in relation to the village, ski trails, golf course, roads, and houses. This ELT had the greatest use, in relation to availability, of any on the mapped portion of the Study Area despite much of the area receiving no use by study animals.

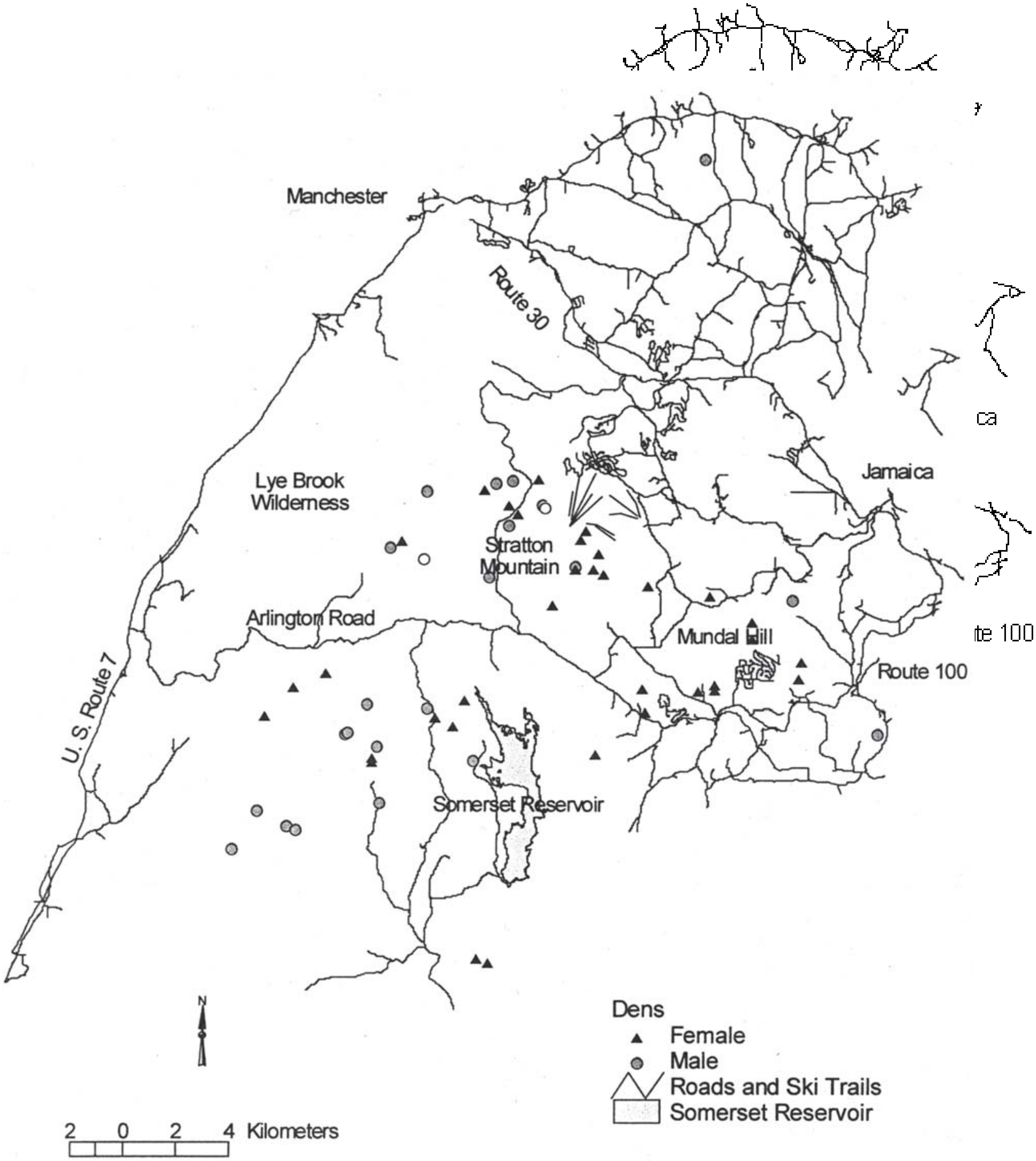

Figure 5.13. Location of 59 black bear dens monitored as part of the Stratton Black Bear Study, 1990-1996.

Table 5.11. Seasonal use of Ecological Land Types (ELT's) by black bears on the Green Mountain National Forest. Area studied included the Stratton Mountain region of the Manchester Ranger District.

		Seasonal Use[1]			
ELT Code	Area km^2	Spring	Summer	Fall	All Locations
402b	30.47	-	-	-	-
403a	17.17	-	-	-	-
403d	12.95	0	-	-	-
405b	139.69	+	+	+	+
405d	14.93	0	0	0	0
605a	3.76	0	-	0	-
605b	29.85	0	0	0	0
605d	8.79	0	+	0	+
610d	9.22	-	-	-	-
612a	9.85	0	+	+	+
621d	5.44	0	0	0	0
702b	62.53	0	0	+	+
702c	2.20	0	0	0	0
702d	7.99	0	0	+	+
703a	31.31	0	-	0	-
703d	46.41	0	+	0	+
705b	16.55	+	+	+	+
705d	12.36	+	+	+	+
710d	14.63	0	0	0	0
902b	69.38	-	0	0	0
902d	11.24	0	-	-	-
903a	184.47	-	-	-	-
903d	54.78	-	-	-	-
905b	39.51	-	-	-	-
921d	7.12	0	-	-	-
	842.63				

+ = preferred *- = avoided* *0 = used in proportion available*

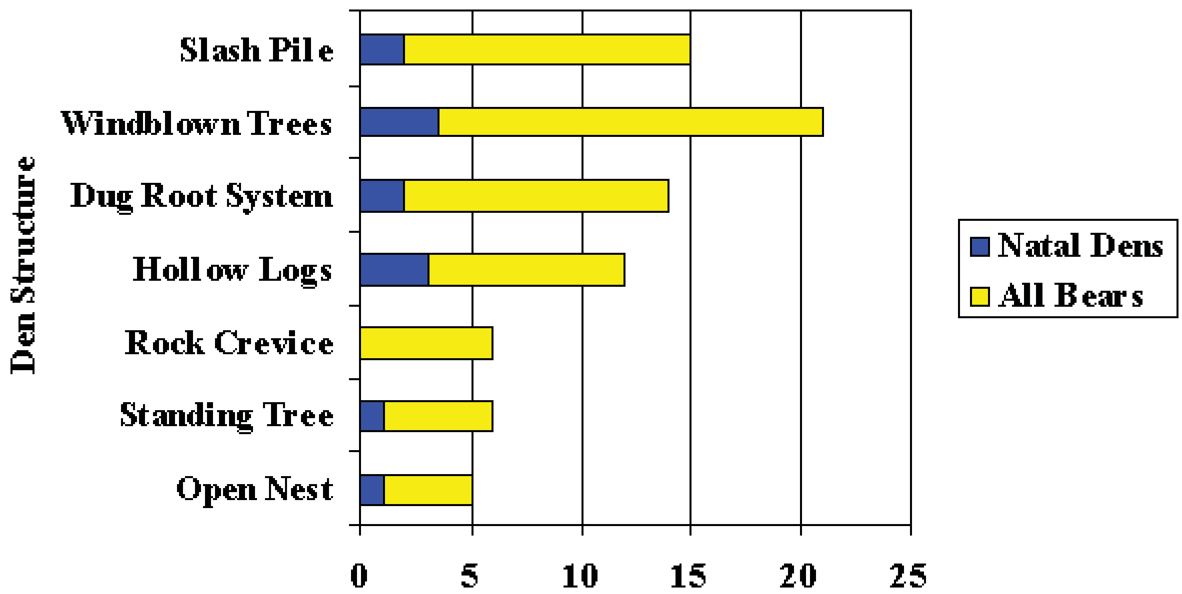

Figure 5.14. Den structure selected by black bears in the Stratton Mountain Study Area, Vermont, 1989-1996.

Females always denned within their normal home ranges, even in food-scarce years when they had ventured considerable distances to find sources of soft and hard mast. Natal dens were located closest to snowmachine and ski trails and were primarily under the trunks of windblown trees and within hollow logs, while none were within rock crevices or caves (Figure 5.14).

The dens of male black bears were located at higher elevations ($\bar{x}$=859 meters, N=25) than female dens ($\bar{x}$=724 meters, N=37) and in more remote areas of their home ranges that were furthest from concentrated human activities. Only female and subadult male dens were found at low elevations nearest to most types of human activities.

DISCUSSION

Home ranges of black bears located within the Study Area were similar to those reported elsewhere. Males roam over large, undefended areas commonly exceeding 100 km^2 (62 $mi.^2$), while most females had home ranges of approximately a third that of male home ranges. Adult female home ranges overlapped other females, and subadult female offspring were allowed home ranges within their mother's home range.

Adult females traveled outside of their home ranges when late summer and fall foods were scarce. They traveled to areas where black cherries, acorns, or apples were concentrated, but did not cross major highways to access fields of feed corn. All females returned to their home ranges to den. A three-year old female chose to den within the first week of October rather than disperse from her home range during a year when natural foods were lacking. Males, particularly dispersing subadults, were not monitored closely outside of the Study Area, but from intermittent telemetry and tag returns from harvested animals, we documented male black bears captured in the Stratton Mountain area traveling throughout bear range in southern Vermont south of Route 103. During the time period of the study, several male bears marked in western Massachusetts were killed in Vermont, and one two-year old wandered 35 kilometers north of the border as far as Bourne Pond before heading back to Massachusetts. Numerous males traveled from the Green Mountain Range to the Taconic Range where they fed in corn fields, but none were documented entering New York. Males also traveled east as far as the towns of Newfane, Windham and Townshend, but no study animal crossed Interstate 91 or the Connecticut River bordering Vermont and New Hampshire. Males dispersed as far north as the Town of Clarendon.

Elevational movements were noted in years of beech nut abundance. During these two years, bears were generally found at higher elevations and further from roads and houses. This resulted in a marked reduction in their availability to hunters and a subsequent lower, harvest by hunters than in other years.

The springtime use of wetlands by black bears in the Study Area was less than anticipated. We expected to find high levels of wetland use as other researchers have found, most notably Dr. Ken Elowe in Massachusetts (Elowe 1984, 1989). He documented black bears feeding in wetlands almost exclusively on skunk cabbage at that time. We were unable to find skunk cabbage within the Study Area, and instead noted their spring diet to consist primarily of one sedge species supplemented by leaves, grasses, roots and nuts – foods found throughout the Study Area and not necessarily limited to wetlands. These same foods also occur in Massachusetts but are apparently passed by in favor of the more succulent skunk cabbage that does occur primarily in wetlands. Ongoing research in Massachusetts is showing that skunk cabbage is much more important nutritionally than other plants (McDonald pers. comm.). Additional research is needed in Vermont to determine specific habitat requirements of skunk cabbage and to inventory its distribution and importance to bears elsewhere in the state.

Although wetlands in the Study Area did not provide key spring foods for black bears to the degree that they do elsewhere, we documented high use during the summer when they fed on jack-in-the-pulpit and jewelweed, used wallows for cooling, and used the dense cover within wetlands as refuge areas and as preferred road crossing sites.

Tall nodding sedge, jewelweed, and jack-in-the-pulpit appeared to be the primary foods during the spring and early summer. *C. gynandra* was found throughout the Study Area at all elevations at disturbed sites such as log landings, skid trails, some blowdowns and beaver dams. Timber harvest and removal, especially that resulting in extensive soil disturbance, appeared to favor its distribution and density. This finding suggests that spring and early summer habitat for black bears might be enhanced by logging conducted in a manner that disturbs the soil in wet areas.

Jewelweed occurred primarily on disturbed sites as well. Largest concentrations were found within the artificial wetlands created by treated waste water sprayfields. It is primarily a summer and early fall food whose importance in black bear diets is increased in drought years and years with poor soft and hard mast production.

Jack-in the-pulpit appeared to be the most important summer food within the Study Area. The nutritional quality, in terms of metabolic energy, of its corm rivals that of acorns and beech nuts and, more importantly, it is consistently available during time periods when other quality foods are normally in short supply. It is found at lower elevations, generally in mature hardwoods, in areas of deep, rich soils and in some forested wetlands. Within the Study Area we documented concentrations of these plants in some areas of mature hardwoods and fewer in adjacent areas that have undergone recent timber harvests. Again, we found the greatest concentrations of plants within wastewater sprayfields. While investigating other resort sprayfields for plant frequency and bear use, we noted variable use by black bears. The volume of wastewater sprayed, field site location, canopy cover, and management affected plant density, whereas plant density and sprayfield location in relation to roads and houses, understory cover, and field management appeared to influence levels of bear use. Our conclusions are that waste sprayfields can be established in bear range without degrading bear habitat if they are planned and managed correctly. We recommend establishing waste sprayfields in mature hardwood stands located between resort developments and undisturbed bear habitat away from roadways. Pipelines should be arranged in grids that include natural features such as boulders and ledges and existing trees. Public access restrictions should rely heavily on signs rather than fencing. Frequent gaps should be provided along the boundary fence, especially on sides facing the best bear habitat. Facility maintenance visits should be as infrequent as possible during the summer and early fall time periods and maintenance workers should not be accompanied by dogs to reduce the risk of displacing bears attempting to forage in these areas.

On National Forest lands within the Study Area, study animals selected for Ecological Land Types occurred on only about a third of the area mapped. Further inventory and interpretation of these ELT's, and field investigations looking at black bear use of these types in other regions of the Green Mountain Forest, are warranted as it may lead to specific habitat improvement strategies for black bears. ELT 612a, a hardwood type with moist, rich soils, was found to be receiving the highest use by black bears. It was also the ELT having the greatest concentrations of jack-in-the pulpit plants. Unfortunately, these plants were found in the largest amounts primarily along roadsides and adjacent to rural housing developments constructed in forested habitats. Few of these plants were found on remote Forest Service land at higher elevations or within the Lye Brook Wilderness Area. Black bears feeding on jack-in-the-pulpit corms face increased risks of being hit by automobiles or coming into contact with humans in other ways. Some bears were documented feeding on jack-in-the-pulpit within beech stands near human developments that were no longer used in the Fall as mast feeding areas. This suggests that areas of jack-in-the-pulpit may be more intensively sought after by bears than beech stands and, that as a food resource, may be more limited in occurrence in habitats used by bears.

Other important bear foods included black cherry, raspberries, blackberries, beech nuts and acorns. Black cherry trees attracted bears during good cherry production years when other foods were lacking. The southwest end of Somerset Reservoir is an area of concentrated black cherry trees and received much use in some years, attracting bears regionally. Blueberries occurred throughout the Study Area in small amounts, but were concentrated only at a prescribed burn site near Grout Pond. High use of this area by black bears suggests potential for improving many other areas within black bear range by similar habitat manipulation measures.

Raspberries and blackberries were utilized by black bears where and when they were most available. Raspberries were most concentrated along right-of-way strips cleared for power lines. Actual amounts of berries available depended to some extent on the timing and method of brush control utilized by the power companies. Potential exists for improving habitat for black bears and other species in these areas of disturbed habitat by simply coordinating brush control programs with power companies to allow for soft mast production.

Blackberries appeared to be the most utilized soft mast species and occurred primarily in areas of recent timber harvest. Their importance was most evident in 1991, a year when both blackberries and beech nuts were plentiful. During that year bears fed heavily on blackberries in early autumn and less on beech nuts until later in the year. This was evidenced by both telemetry locations and from an observed scarcity of “baskets” or “nests” constructed within beech stands prior to nut drop. It appeared that most beech nut feeding occurred on the ground that year rather than from the more labor intensive method of climbing the trees and breaking branches to obtain nuts.

Beech nuts were used heavily during two of the six years of the Study. Their availability influenced bear movements, timing of denning, weight gain and perhaps survivorship of adult bears during hunting seasons as well as the mortality of cubs and subadult bears during the spring and summer seasons. We noted variable use of different beech stands with greatest use occurring in remote stands. In addition to black bears favoring beech stands remote from concentrated human activities, use was variable within each stand. Areas where researchers observed high use had an availability of water and physical features that provided an abundance of concealment cover. Hiding cover was provided by either a thick understory of young hardwood trees and conifer trees, or boulders, ledges, and overall rough topography. Conifer trees within beech stands are especially important for providing hiding cover after leaves have fallen from deciduous trees and also as “baby sitter” trees whose scaly bark offer easy climbing and security for cubs.

The importance of protecting mast stands is reinforced by the fact that bears in southern Vermont have access to few alternative, quality fall foods. In many other areas of New England, bears routinely switch to feeding in fields of feed corn in the fall and to skunk cabbage in the spring when hard mast is unavailable, but in the southern Green Mountains of Vermont these alternate resources are limited. Loss of Vermont’s existing beech stands would create additional nutritional stress, stimulate greater seasonal movements, result in higher rates of mortality, and force additional bears into nuisance situations. Habitat management objectives for all Bear Management Units should be to maintain existing critical hard mast stands in remote areas while providing, through a program of carefully-planned timber harvests, controlled burns and improved management of powerline right-of-ways for an abundance of areas producing soft mast food species available for black bears. Expansion plans of mountain resorts should incorporate the needs of black bears to access areas of hard and soft mast as well as areas where other key plant foods are concentrated.

CHAPTER 6

BLACK BEAR RESPONSES TO HUMAN ACTIVITY

INTRODUCTION

Black bears require forested landscapes to fulfill their foraging, security, movement and denning needs. They are a long-lived, highly intelligent species that have adapted to most forested habitats across North America. Despite their intelligence and adaptability to different forested environments, black bears were nearly eradicated from most of their range during the nineteenth century due to unregulated hunting and land use practices which reduced the forested land base. Throughout most of the Northeast sightings of black bears were rare until the latter half of this past century when reforestation on a widespread scale again provided suitable habitat and when bounties on them were replaced with carefully regulated hunting seasons thereby allowing populations to reestablish themselves.

Today, the largest populations of black bears exist in the most remote and expansive tracts of forests, such as those in Maine and in the northern parts of New Hampshire and Vermont, which are relatively unbroken by paved roads and housing developments. Many other states, with large metropolitan areas along the eastern seaboard, have reduced populations of black bears. Scientists believe habitat fragmentation to be a serious concern for black bears across their range and especially problematic in areas experiencing rapid increases in human population growth such as in the southeastern United States. Pelton (1990) stated that at least 30 relatively disjunct populations exist in 13 southeastern states, each with differing degrees of isolation and vulnerability to human impacts. This problem is perhaps most evident in Florida and Louisiana which, until recently, had large black bear populations comparable to the Northeast. Rapid habitat development in these states has reduced their numbers to small, genetically non-viable levels which now face uncertain futures.

Highways and roads have several direct and indirect negative impacts on black bear populations. Habitat fragmentation, the hardest indirect impact to define, occurs when highways and other developments create a partial “barrier effect” which limits black bear population movements and distribution by isolating sub-populations, restricting access to seasonally important foods, reducing rates of immigration and emigration, limiting breeding opportunities (gene flow), and ultimately causing local extinctions. Apparently, roads and associated developments can be a semi-permeable barrier for black bears (Berringer et al. 1989), with the permeability being a function of the amount of human activity, traffic volume (Carr and Pelton 1984, Brody and Pelton 1989), and perhaps even whether or not a road is paved (Miller 1975).

Up until the past couple of decades, black bear management consisted primarily of regulating the legal harvest in a manner that ensured that the population was sustainable. Management objectives in many states, including Vermont, now revolve around maintaining wild, free-ranging, viable populations of black bears as well as the conservation of their habitat.

To do this in the face of habitat loss and fragmentation, wildlife managers emphasize conserving large blocks of interconnected forest land and identifying and protecting the most critical components of black bear habitat. Although evaluating direct impacts from development has been relatively easy, measuring and mitigating for the more elusive indirect impacts has been difficult and controversial. The Stratton Mountain Black Bear Study was created to help provide wildlife managers with additional knowledge of how black bears utilize their environment in relation to the development and recreational activities of humans. Specifically, this chapter reports on the spatial requirements of the population as well as of individually monitored bears whose home range use and seasonal movements were affected by houses, camps, roadways, recreational activities, and availability of human foods.

METHODS

Methods involving the capture, monitoring of movements, and analysis of home range and habitat use of study animals were reported in previous chapters, as were the sex and age categories and seasonal time periods used in our analyses. In this chapter, we analyze the spatial distribution of study animal movements/locations in relation to human cultural features found within and adjacent to their home ranges. Cultural features were classified as either permanent or seasonal houses, or as one of four classes of roads defined by traffic volume and surface type. Specifically, these road classes were:

Class I - Highway with greater than 1,000 vehicles per day; paved road surface (includes Routes 7, 9, 11, 30, and 100)

Class II - Paved road with 0-1,000 vehicles per day

Class III - Maintained, year-round gravel roads, less than 200 vehicles per day

Class IV - Seasonally used dirt and gravel roads, generally less than 50 vehicles per day (includes gated USFS roads, haul roads, and logging roads)

Individual locations of study animals were examined in relation to cultural features within the Study Area by creating “buffer areas” which consisted of concentric bands in 100-meter intervals around each cultural feature out to a distance of 1 kilometer (or ten 100-meter bands) from each feature within the Study Area. For this analysis, only those bear locations (“points”) within one kilometer of a cultural feature were used due to limitations in telemetry accuracy. The number of study animal location points used ranged from 3155 points for home range and road impact analysis to 1592 points for houses in each analysis. Only bears with 30 or more locations per season were used in this portion of the analysis. We conducted use/availability analysis on a seasonal basis for each incremental buffer area using Arcview-generated 10 X 10 grid cells, or pixels, to facilitate evaluation of selection and avoidance using methods of area available and observed use proportions (Neu et al. 1974). Differences in distribution (which areas were used out of proportion to availability) were examined using Chi-square analysis. If the Chi-square analysis was significant, simultaneous Bonferonni confidence intervals were calculated to determine which buffer distances were selected or avoided (Byers et al. 1984). Significance of all tests were considered to be p=0.05.

RESULTS

Effects of Houses

Only seven of 13 female black bears (54%) had home ranges containing both seasonally-occupied houses (summer camps and ski chalets) and permanent residences, while all adult (N=38) and subadults males (N=4), with the exception of one yearling male, had both types of houses within their home ranges. Bears having home ranges not containing houses were located primarily on National Forest lands and bears with the greatest number of houses within their home ranges were located adjacent to the Stratton Mountain Ski Resort. Subadult study animals, whose home ranges typically included their mothers' home ranges, had home ranges with densities of houses similar to adult females (mean=3.8/km^2 vs. 3.5/km^2). Male bears had larger home ranges which included areas containing houses as well as relatively remote areas and consequently had significantly lower densities of houses (mean=1.64/km^2) within their home ranges (Table 6.1). Females were usually located closer to houses than males, while subadult bears selected for habitats closer to houses than adults. Females accompanied by cubs occupied areas near houses more than other adult females (Table 6.2).

Table 6.1. Density of roads and houses within home ranges of adult and subadult black bears in the Stratton Mountain Study Area, 1990-1995.

		Density (No./km^2)	
Sex and Age Class	**Number of Home Ranges**	**Houses**	**Roads (km)**
Adult Male	14	1.64	0.61
Adult Female	24	3.53	0.84
Subadult	11	3.80	0.92

Chi-square tests of independence were used to test the Null Hypothesis that black bears use the areas near houses in proportion to availability (Marcum and Loftsgaarden, 1980). Our results rejected the Null Hypothesis as they revealed that adult black bears did not frequent areas near houses on the Stratton Mountain Study Area in proportion to availability, but instead demonstrated avoidance of houses to varying degrees, throughout all seasons. Only subadult study animals failed to avoid houses in each season, exhibiting avoidance only during the fall period. Adult males showed the greatest avoidance during the summer to seasonally occupied houses (mean=400 meters) and during the fall to permanently occupied houses. Adult females avoided year-round residences the most in the spring season (mean=400 meters) while showing least avoidance (mean=200 meters) during the summer to both house types (Table 6.3).

Table 6.2. Summary of telemetry locations in relation to cultural features.

	Roads			Houses		
	Locations within 1 km	**Mean distance**	**Percent within 1 km**	**Locations within 1 km**	**Percent within 1 km**	**Mean distance**
All Bears	2576	635	81.65%	1592	50.46%	2396
Females	1571	611	82.38%	1110	58.21%	2027
Males	1005	674	80.53%	482	38.62%	2961
Females with Cubs	649	579	82.57%	513	65.27%	1541
Adult Bears	2172	640	82.12%	1280	48.39%	2592
Subadult Bears	404	611	79.22%	312	61.18%	1381
Spring	529	570	84.37%	362	57.74%	1600
Summer	1470	559	86.07%	910	53.28%	2213
Fall	577	846	70.37%	320	39.02%	3385
1990	289	582	85.00%	238	70.00%	1394
1991	704	650	80.55%	437	50.00%	2068
1992	391	684	79.47%	223	45.33%	3517
1993	480	534	85.87%	217	38.82%	2706
1994	441	726	76.56%	262	45.49%	2577
1995	271	591	86.31%	215	68.47%	1758

Table 6.3. Summary of black bear avoidance distances to seasonal and year-round human residences in the Stratton Mountain Study Area, 1990-1995. Distances were analyzed in 100 meter increments from houses using chi-squared tests of independence.

	Seasonal Houses (meters)			Permanent Houses (meters)		
Bears	**Spring**	**Summer**	**Fall**	**Spring**	**Summer**	**Fall**
Adult Male	200	400	100	200	200	200
Adult Female	200	200	300	400	200	300
Subadult	0	100	300	0	0	300

Avoidance of Roads

All study animals had roads within their home ranges (n=49, range 0.29-2.87 km/km^2). Mean road density was least for adult males (0.61 km/km^2) and greatest for subadult black bears (9.92 km/km^2). Road densities within adult female home ranges were similar to subadults (Table 6.1). There were no home ranges which exceeded an overall road density of 1.41 or a density for paved roads greater than 0.46 km/km2.

Eighty-two percent (2,576) of all study animal location points were within one kilometer of roads. For data pooled for all bears, the Null hypothesis that bears used the area near roads in proportion to availability was rejected; the telemetry locations were not the same as random points for road surface classes 1, 2, 3, and 4. Black bear locations were not random across the landscape in relation to roads.

Pooling data for different age and sex groups revealed that adult male bears selected for areas furthest from roads with a mean distance of 674 meters. Adult female and subadult black bears had similar mean distances; they were found from roads at 611 meters each. Females accompanied by cubs-of-the-year (COY) were most often found closest to roads (mean=579 meters). Seasonally, bears selected for areas closest to roads during the summer period and significantly further from roads ($P<0.05$) during the fall (Table 6.4).

All groups of bears used the area within the first 100 meters from roads less than expected (available), and adult females in general avoided areas from roads out to 300 meters, while adult males avoided paved roads the most, avoiding Type 2 paved roads out to 400 meters (Table 6.4). Some individual adult animals showed avoidance to 600 meters away from roads within their home ranges in some years, although levels of avoidance varied greatly between different years and between individuals (Table 6.5). All bears were located furthest from roads during the fall season. At least some of the variance in the distances that bears were found from roads can be attributed to fluctuations in beech mast availability. During time periods that beech mast was abundant, black bears were documented being significantly further ($P<0.05$) from roads than for seasons, both fall and early spring, when beech mast was not available (Table 6.6).

Table 6.4. Summary of selection analysis of buffer distances within one kilometer of two different road types. For data pooled for all bears, the null hypothesis was rejected (distribution was not random) for each road type. Those statistically significant are highlighted.

		Season and Buffer Interval [(+) preferred (-) avoided]		
Road Type	**Bear Group**	**Spring**	**Summer**	**Fall**
I	Adult Females	800-900m (+)	0-100m (-)	0-100m (-)
	Adult Males	0-100m (-)	100-200m (-)	100-200m (-)
	Subadults	ns	ns	ns
II	Adult Females	500-600m (+)	200-300m (+)	0-100m (-)

Table 6.5. Summary of avoidance distances to different road classifications by three study animals who were the most intensively monitored during 1990-1995, and whose home ranges included several roads. Only avoidance distances determined statistically significant (P=0.05) for locations pooled for all seasons are shown.

Study Animal	**Year**	**Avoidance Distance**	**Road Classification**
Adult Male No. 11	1992	400m	II
Adult Female No. 15	1992	400m	I
	1994	200m	I
	1991	600m	II
	1992	400m	II
	1992	200m	III
	1994	200m	III
Adult Female No. 28	1991	500m	II
	1993	400m	III

Table 6.6. Effects of beech mast production on spring and fall bear locations in relation to distance from roads.

	Distance to Roads (meters)					
	All Bears			Adult Females		
Spring Mast Availability	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Good to Excellent**	263	664	501	155	644	491
Poor to Fair*	364	486	388	181	494	373

	Distance to Roads (meters)					
	All Bears			Adult Females		
Fall Mast Availability	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Good to Excellent***	399	896	665	173	980	682
Poor to Fair****	478	808	840	414	834	1,118

** Pooled spring location for 1991, 1993 and 1994.*
*** Pooled data for 1992 and 1995.*
**** Pooled fall locations for 1991 and 1994*
***** Pooled fall locations for 1990, 1992-93 and 1995*

The importance of remoteness in affecting black bear use of beech stands was examined in 1991 and 1994 in the Stratton Black Bear Study Area as well as statewide as part of a Master of Science Thesis titled *Development of a Quantitative Procedure to Assign a Value Rating to Beech Stands as Black Bear Habitat* by Dan Wolfson (1992). Working in conjunction with this study, Wolfson developed a Fidelity Rating for individual beech stands based on the number of beech trees within each stand exhibiting evidence of bear climbing activity (i.e., claw marks) and the number of times bears had climbed these trees throughout different time periods (Wolfson and Hammond 1992). Examining 42 beech stands with varying intensities of bear use revealed that the 26 stands ranking highest in bear use were almost all greater than one kilometer from roads with a mean distance of 2.1 kilometers (Figure 5.10). Conversely, the four stands ranking lowest in use were all comparatively closer to roads (mean=0.4 km). Several stands were checked, but then not included in the data base, that exhibited only old use by bears. Each of these was located within 200 meters of roads, houses, or within areas of high levels of human activity.

Many of the study animals monitored had home ranges contained within Class 1, 2, and 3 roads where it appeared that they used these roads as their home range boundaries and seldom crossed them during daily and seasonal movements. This was most apparent for some adult male and female study animals (Figures 6.1 and 6.2) in years of natural food availability.

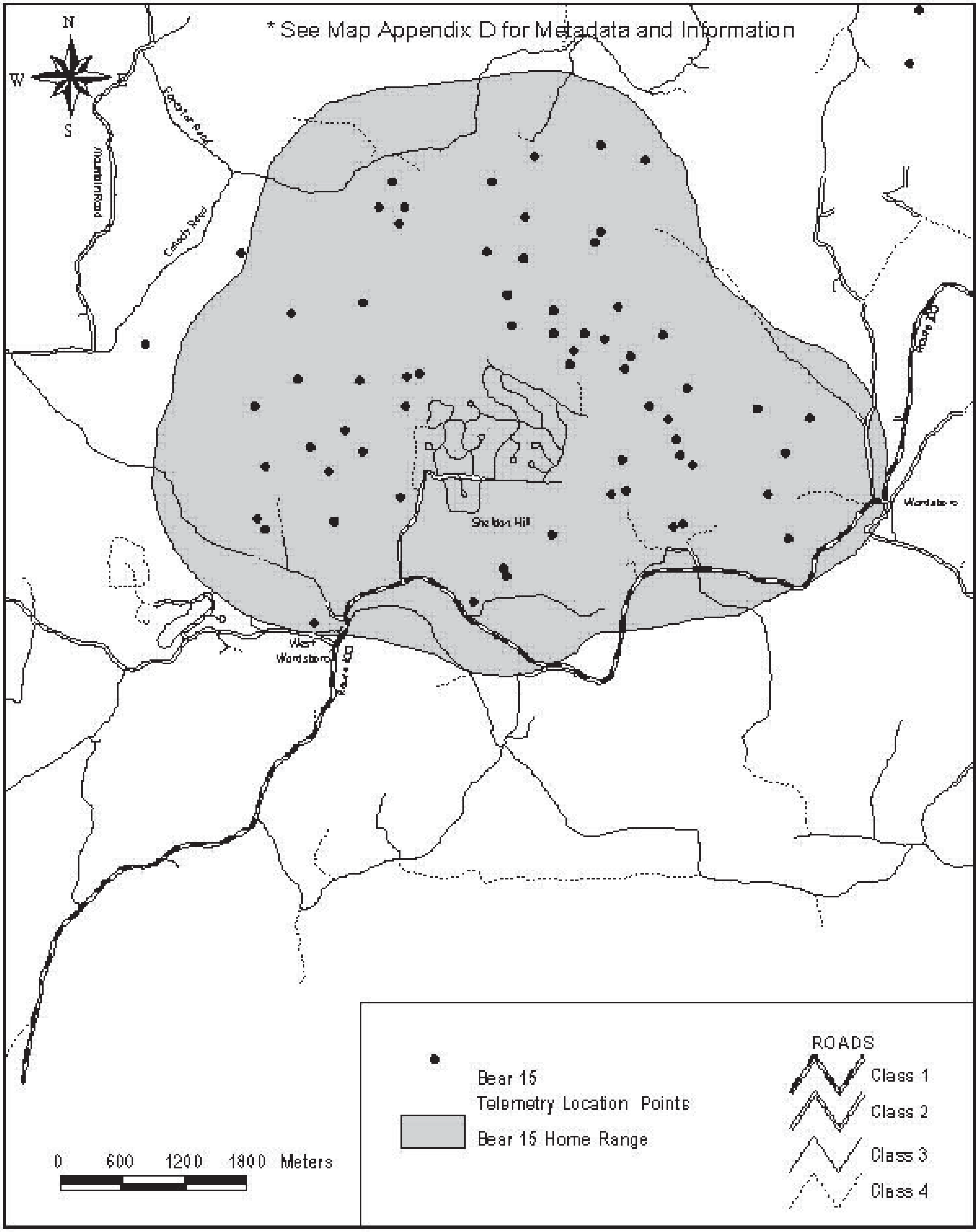

Figure 6.1 Home range of adult female black bear No. 15 in 1994.

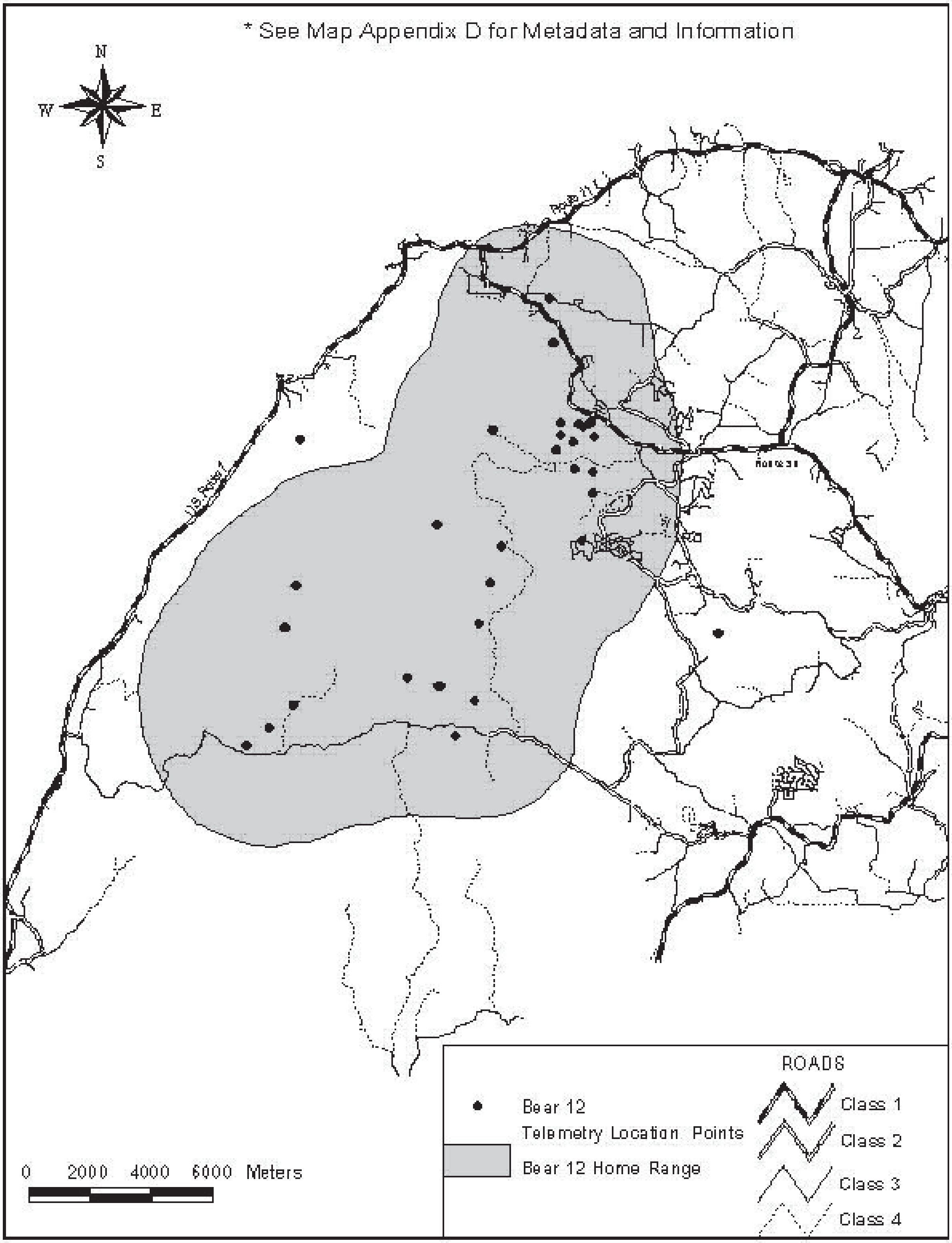

Figure 6.2 Home range of adult male black bear No. 12 in 1991.

Road Crossing Behavior Including Barrier Effect

During seasonal movements outside of their home ranges to reach feeding areas, at least twelve male black bears crossed Class 1 roads with high traffic volumes such as U.S. Routes 7, 30 and 11 (Figures 6.3 and 6.4). In general, male bears crossed Class 1 and Class 4 roads more than females. Within their home ranges, subadult male bears were more than twice as likely to cross Class 1 roads than adult males and five times as likely to cross them as adult females (Table 6.7). Only one adult female was documented crossing a Class 1 highway. Female Number 15 crossed Route 100 on the southern border of her home range several times in different years. While classified for our purposes as a Class 1 highway, Route 100 has only 1400 vehicles/day compared with Route 7 having 5700/day and Routes 11 and 30 at 2800/day and 2900 vehicles/day respectively. Females, while reluctant to cross paved roads with high traffic volumes, crossed Class 2 and 3 roads more than adult males. We documented no instances of subadult females crossing Class 1 roads. Subadult females, generally existing within their mothers' home ranges, crossed Type 2 and 3 roads at higher rates than other bears. Subadult bears crossed Class 4 roads at approximately the same rate (47% for males and 42% for females) while adult males crossed them at more than twice the rate of adult females (99% vs. 40%). Sites where male bears had crossed Class 4 roads were encountered during capture operations using trained bear hounds. Often the crossing site was where the bear had been feeding on berries, Jack-in -the-pulpit roots, or insects along these remote roads.

All bears crossed paved roads (Class 1 and 2) more during years of food scarcity, such as in 1991 and 1994, than when foods were abundant. During these two years, when study animals were believed to be nutritionally stressed and many took long sallies outside their home ranges, they crossed Class 1 roads at a rate eight times that which they crossed in years when food was more abundant (Table 6.8).

Class 1 roads, especially those with automobile traffic volumes greater than 1400 vehicles/day, appeared to preclude female bear movement, and a partial, or semipermeable, barrier to male bears. The barrier effect of highways with high traffic volumes was also apparent for some male bears who moved to areas adjacent to highways, but did not cross. On four different capture operations, researchers for this project pursued bears with the aid of trained hounds from Stratton Mountain through the Lye Brook Wilderness to where the animals ended up along Route 7 without crossing. On each occasion the pursued animal reached the highway fence and then moved parallel to the road for distances of up to two miles without crossing either the fence or the highway. We did not document any instances of bears crossing Class 1 roads when being pursued by dogs, although on several occasions bears crossed Class 2 roads during capture operations. This barrier effect is probably compounded by other landscape features associated with roads that were not analyzed separately but where some trends were noteworthy. We noted that bears avoided crossing roads along areas that contained mesh fences, multiple parallel roads, open fields, steep ledges, solid lines of steel plate guard rails, and clusters of houses. One crossing area which had been used at least eight times within the first two years of the study was not used again by study animals after a quarter mile stretch of continuous steel guardrail was installed at the crossing area.

An area in the town of Winhall in the northern portion of the Study Area was enclosed by Class 1 roads (Routes 30, 11, and 100) and appeared to be frequented only by male bears (Figure 6.3). We attempted to capture bears in this area and succeeded in only capturing males who did not remain within this area bounded by highways for an extended period. Capture efforts ended after several months of not capturing a female nor encountering any evidence that indicated any existed in the area.

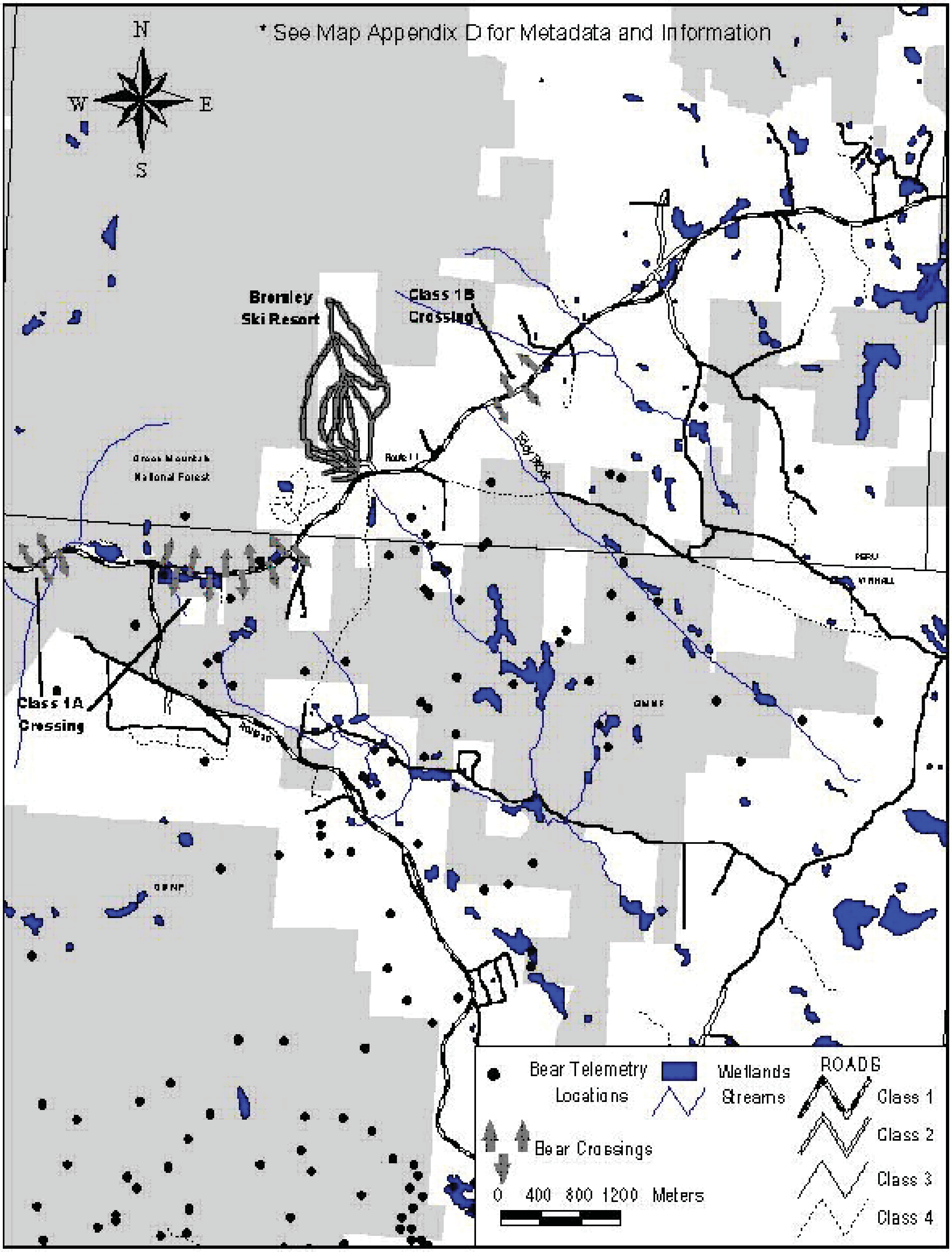

Figure 6.3 Black bear telemetry locations in relation to major highways Routes 11 and 30 in southern Vermont.

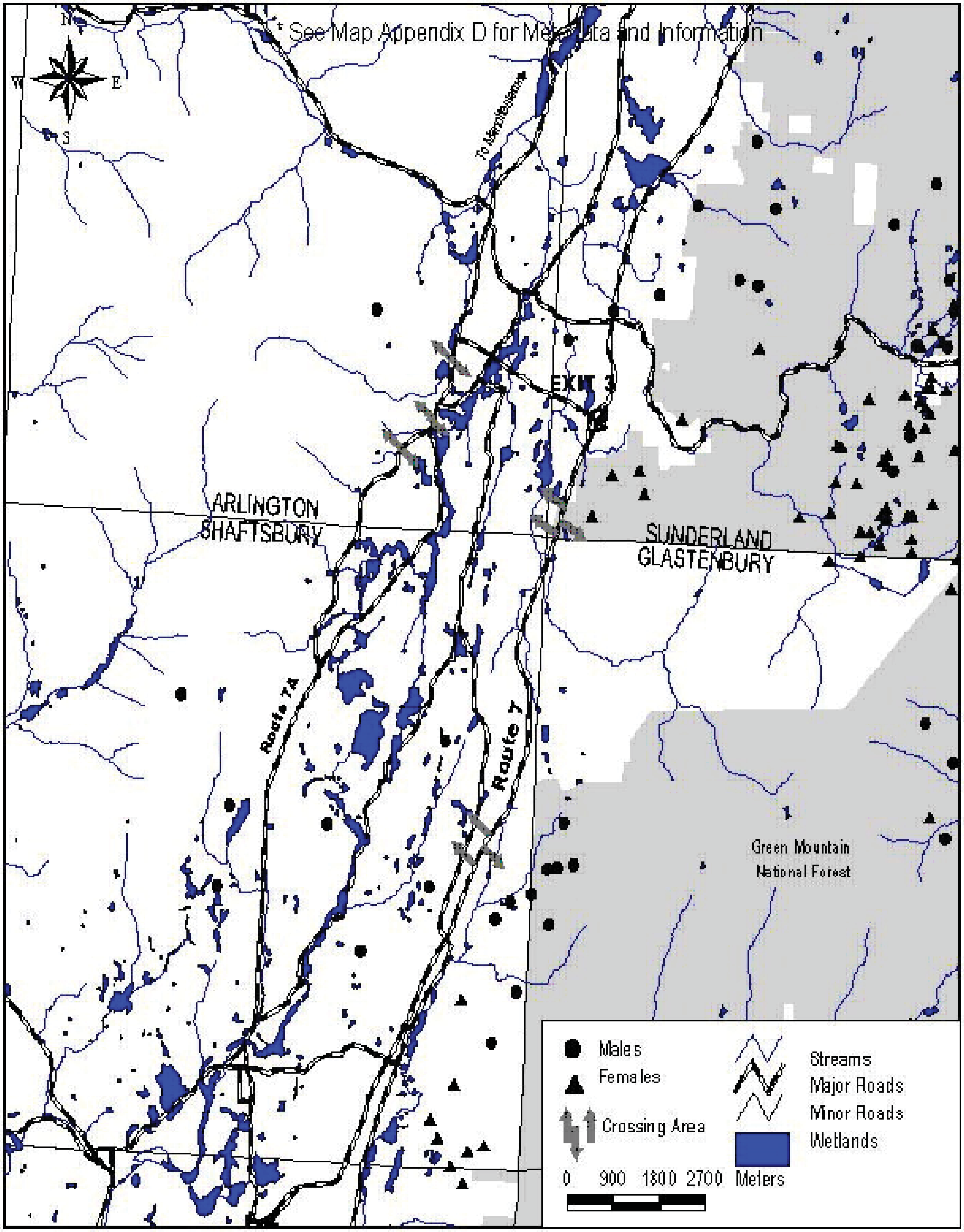

Figure 6.4. Male and Female black bear telemetry locations in relation to U.S. Route 7. All crossings of this highway were by male bears seeking corn. Females did not cross.

Table 6.7. Number of times black bears crossed roads within their home ranges and rate* of crossings for different road types based on radio telemetry data.

			Rate of Crossings (%) For							
			Road Types I-IV				Combinations of Road Types			
Bears	No. of Loca-tions	No. of Cross-ings	I	II	III	IV	I & II	I, II & III	III & IV	All Types
Adult Males	625	466	2.6	24.3	23.7	98.6	26.9	50.6	122.3	149.2
Adult Females	1420	757	1.4	38.2	26.8	40.3	39.6	79.9	67.1	120.2
Subadults	624	437	5.4	43.9	46.8	43.9	49.3	96.1	90.7	140.0
(Male)	(238)	(149)	(7.1)	(21.8)	(42.0)	(47.1)	(28.9)	(70.9)	(89.1)	(118.0)
(Female)	(386)	(288)	(0.0)	(57.5)	(49.7)	(42.0)	(57.5)	(107.2)	(149.2)	(91.7)
All Males	863	615	9.7	46.1	65.7	145.7	55.8	121.5	211.4	267.2
All Females	1806	1045	1.4	95.7	76.5	82.3	97.1	173.6	158.8	255.9

Table 6.8. Number and rate* of crossing of all bears of paved roads (Types 1 and 2) during years of food scarcity and abundance, 1990-1995.

		Type 1	Type 2	Type 1 & 2
Food Availability (Years)	Number Locations	No. of Crossings (Rate)	No. of Crossings (Rate)	No. of Crossings (Rate)
Abundant (1990, 1991, 1993 & 1994)	1953	10 (0.2)	330 (8.4)	340 (8.7)
Scarcity (1992 & 1995)	716	25 (1.7)	154 (10.6)	179 (12.5)

* Rate = $\frac{\text{Number of Crossings}}{\text{Total Locations}} / 2 \times 100$

Characteristics of Road Crossing Areas

Most of the black bears studied did not cross roads at random but were instead found to select for specific road crossing sites within their home ranges and seasonal movement corridors. These areas tended to have forest cover on both sides of the road, contained dense concealment cover, had nearby concentrations of food plants, were on road curves with limited visibility, and were in areas where roads bisected wetlands, streams or ridgetops (Table 6.9). All paved highway crossing sites were characterized by some combination of these features and were most often used as a connection, or bottleneck, between two areas of extensive forested habitat. Although crossing areas were less frequent, their site specific characteristics were more obvious along highways with greater automobile traffic volume and in areas of more concentrated human development. Crossing sites within these areas were limited to small segments of highway between centers of human development where vegetation, especially understory softwood species, was close to both sides of the road and where no steep ledges which would impede travel were present. These crossings were often further limited to short sections of highway where there were gaps in the guard rails of at least 20 meters. In the majority of cases, the presence of a solitary house or two did not prevent bears from using a crossing area. Multiple parallel roads bisecting segments of a bear movement corridor were avoided by bears. Roadside fences may also act as a partial barrier to bear movement as several times bears were documented traveling along fences and not crossing either the fence or the highway. At several known crossing sites that included fences, gaps were found in the fence which allowed for easy passage.

Table 6.9. Comparison of nine characteristics of 33 black bear crossing areas of paved roads within the Stratton Mountain Study Area. Crossing areas were identified as segments of roads where multiple bears were documented crossing during 1990-1995.

	Characteristic	Number of Crossing Areas (% of Total)
1.	Forested on both sides	33 (100)
2.	Lacking parallel roads[a]	32 (97)
3.	Stream within 100m	28 (85)
4.	Road curves within 100m	27 (82)
5.	Conifer concealment cover	26 (79)
6.	Houses nearby[a]	21 (64)
7.	Known nearby food source[b]	17 (52)
8.	Wetlands nearby[a]	15 (45)
9.	Located on ridgetop	4 (12)

[a] *Within 400m of crossing area*

[b] *Concentrations of apple trees, jack-in-the-pulpit, blueberries, or oak trees*

Study animals who routinely crossed roads within their home ranges did so repeatedly at the same locations. Most adult black bears had one or two crossing sites within their home ranges. Female Number 13 was notable in that she displayed less avoidance of roads than other study animals and crossed them significantly more than other adult females, including using five crossing sites on Class 2 roads (Figure 6.5). She is distinctive as being the only study animal we documented crossing under the highway using a stream culvert.

Road crossing sites were not only located within individual home ranges but were also located within bear travel corridors which were regionally important due to the relatively large numbers of black bears using these corridors to access seasonal foods or to link bear ranges and sub-populations. Two major travel corridors in the Study Area were the Sage Hill Corridor, linking bears from the large forested regions of Stratton Mountain and the Lye Brook Wilderness Area with the more fragmented habitat to the east, and the Route 100 Corridor which facilitated movement between two large blocks of productive habitat bisected by the highway (Figure 6.6). Crossing areas within both corridors are fragmented by stretches of houses and steel guardrails that restrict the actual road width of the crossing area.

In one case where multiple highways bisected a travel corridor, black bear movement was not linear. Black bears crossing between the Green Mountain and Taconic Ranges had to cross both Routes 7 and 7A in the valley bottom. Within the travel corridor, the highways were separated by nearly a mile of sparsely developed land that contained numerous wetlands and streams. Rather than crossing directly from one mountain range to the other, black bears crossed one highway and then often spent several days feeding and traveling along the wetlands and streams before crossing the second highway via one of several locations where the highway bisected a stream or wetland.

Nocturnal and Crepuscular Behavior

The nocturnal and crepuscular behavior of individual study animals was monitored throughout the hours of forty-four nights during the summer of 1993. At one-half hour intervals commencing one hour prior to sunset and ending one hour after sunrise, technicians determined if the study animal was moving or “active” by whether or not the transmitter signal varied in strength. Animals whose transmitter signal strength remained constant were assumed to be inactive while those with variable signal strength were recorded as being active. For the purpose of this study, the crepuscular time period was considered to be one hour prior to and one hour post sunrise and sunset respectively.

Of the study animals monitored, crepuscular activity was similar among all bears on both developed land and on the more remote Forest Service lands. Activity rates were significantly different ($p>0.05$), however, for the night time period between twilight and dawn. Black bears with home ranges which included high densities of houses, roads and large amounts of privately owned land were more likely to be active during the nocturnal hours than bears with home ranges in the more remote areas with less human development. Female bears in particular, were more active on private lands at night as they were nearly twice as often recorded as being active than those females who had little or no houses and roads within their home range boundaries (Table 6.10.)

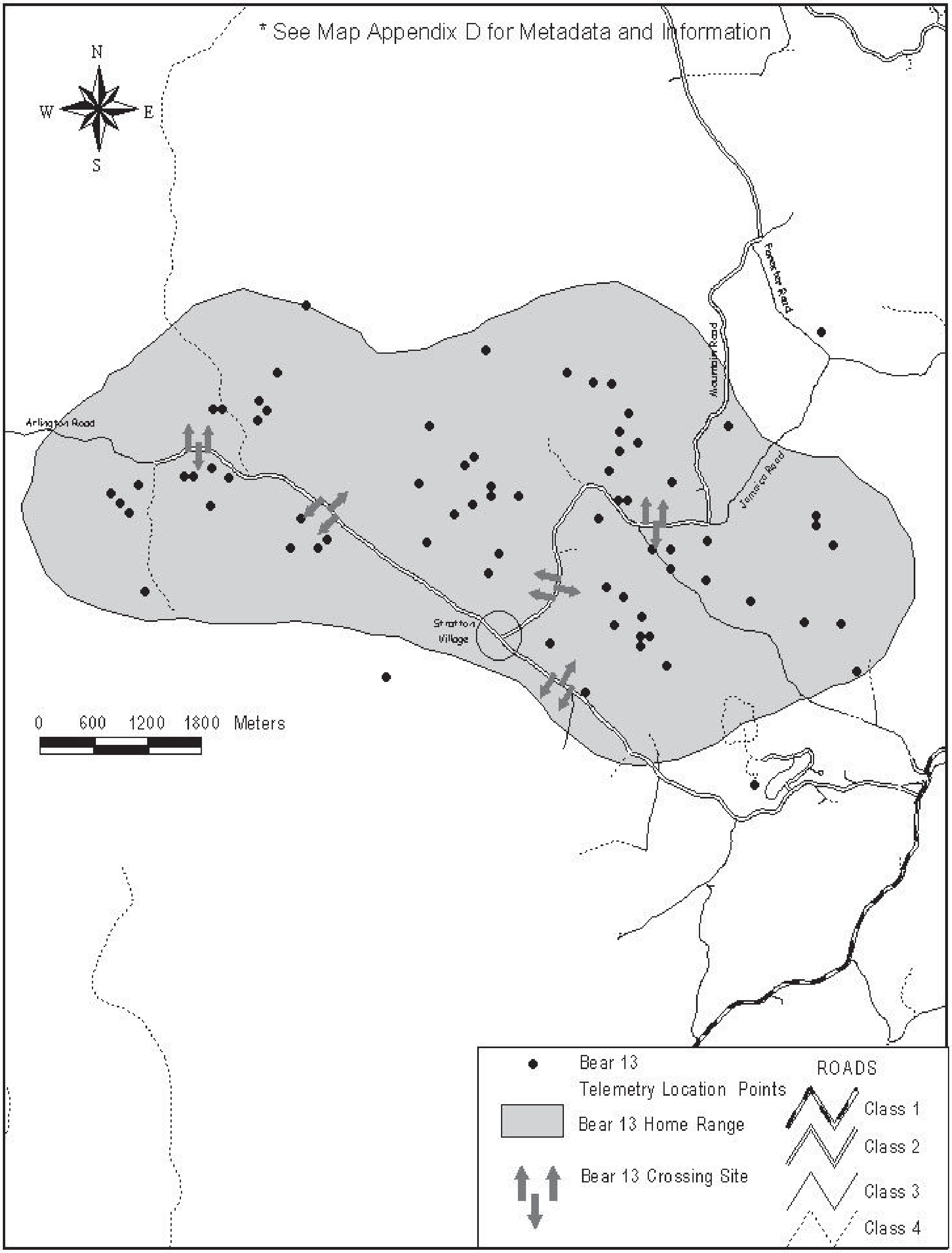

Figure 6.5 Home range of female black bear No. 13 in 1990 and her five primary road crossing points of Class 2 roads.

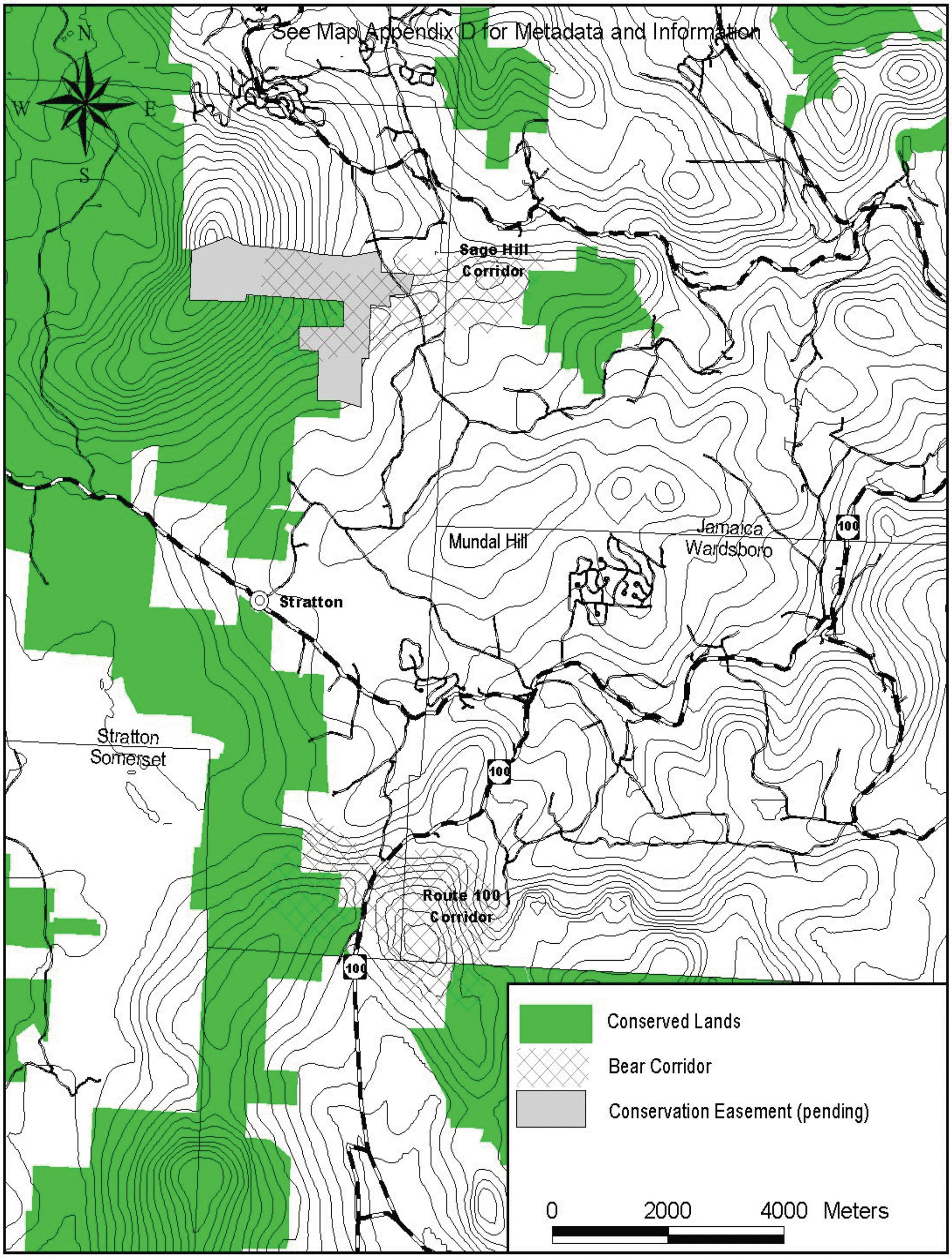

Figure 6.6 Map of the southeastern portion of the Stratton Mountain Study Area showing federal and private land ownershipas well as Sage Hill and Route 100 black bear corridors.

Table 6.10. Activity rates for black bears on private, mostly developed lands, and on more remote USFS lands during crepuscular and nocturnal time periods. Activity rate was measured using percent of time in one-half hour intervals that study animals were active during 44 monitoring nights throughout the time period of July 6 to August 31, 1993.

	Activity on Developed Lands		Activity on Undeveloped Lands	
Bears	**Crepuscular**	**Nocturnal**	**Crepuscular**	**Nocturnal**
Males (N=21)	91.2 %	57.5	93.2 %	46.0
Females (N=24)	92.3%	61.9	86.7%	31.8
All Bears (N=45)	91.9%	60.3	90.3%	39.4

Study technicians reported that, if a study animal crossed a Class 1 road while being monitored, the crossing usually took place after sunset and prior to sunrise. We counted traffic volume on four occasions in July, 1993 for Route 30 in a stretch of highway that the Vermont Agency of Transportation had reported as having 2900 vehicles per day (VAOT 1996 Traffic Flow Map published June 1998). During the dawn hours of 0430-0530 there were 5 to 10 vehicles per hour and during the time period 0530-0630 this had increased to 50-75 vehicles per hour passing the same point on the highway.

Den Site Location in Relation to Winter Recreational Activity

The intrusion of people into wildlife habitat can result in the undue stress of wildlife populations. (Anderson 1991). During the winter months, for example, sudden increases of recreational activities within wildlife habitats may cause negative impacts to wildlife by increasing energy expenditures at a time when food is of low nutritional value or when animals are hibernating. Although the impacts of snowmobiles on bears has not been recorded in the literature, negative impacts have been reported for bald eagles *Haliaeetus leucocephalus* (Stalmster and Newman 1978), small mammals (Bury 1978), and white-tailed deer *Odocoileus virginianus* (Dorrance et al. 1975; Richens and Lavigne 1978).

Only Goodrich and Berger (1994), studying black bears in Nevada and California, have attempted to describe the impacts of winter recreation on hibernating bears. In areas with high levels of alpine skiing and snowmobile activity, they reported that black bears entered winter dens 31 days earlier and were more likely to abandon their dens when disturbed by researchers. Other researchers have found that, following den abandonment, bears lost 25% of their body weight as compared to a 16% loss for bears who did not abandon their dens (Tietje and Ruff 1980). Lundberg et al. (1976) speculated that disturbance of bears during the transition into hibernation may cause death from starvation and urea poisoning. Mack (1988), studying the ecology of bears in Montana, hypothesized that bears may minimize winter fat loss by selecting dens in remote, undisturbed areas of their home ranges.

In the Stratton Mountain Study Area, we investigated spatial relationships between black bear den selection and human winter recreational activities. Specifically, we attempted to determine if bears avoided selecting den sites adjacent to the alpine ski trails on Stratton Mountain or near the network of snowmobile trails located throughout the Study Area.

The distance from the den site to the nearest ski or snowmobile trail was recorded at fifty-nine den sites during the winter denning periods from 1989-1996. Previously, we reported that the dens of male black bears were located at higher elevations than female dens and tended to be within the more remote areas of their home ranges. Only female and subadult male dens were on the more developed and less remote private lands. Adult males selected den sites in areas furthest from houses and roads.

The den sites of adult males were found to be located further from snowmobile and ski trails than either female or subadult dens (Table 6.11). Only three males (19%) denned on Stratton Mountain, none of which were within 300 meters of ski trails. Two adult females, however, were found denning within 250 meters of active ski trails, with one denning only 25 meters from a trail's edge within a network of ski trails. Sixty-one percent of adult female dens and thirty-seven percent of subadult dens were found within 250 meters of snowmobile trails, whereas only one male was found denning within 250 meters of a snowmobile trail.

Table 6.11. Mean distances (in meters) between winter recreational activity and black bear den sites on the Stratton Mountain Black Bear Study Area, Vermont, 1990-1996.

Age/Gender Class	Number of Den Locations	Mean Distance to Recreational Trails (m)	Std. Dev.	Range (m)
Adult Female	26	362	71	25-1375
Adult Male	17	691	114	125-2000
Subadults	16	581	167	100-1800

We anticipated that adult male bears would den further from snowmobile and ski trails than females and subadults since this trend was previously noted in relation to road and house avoidance. We were surprised, however, that our data appeared to imply that subadults selected dens further from recreational trails than adult females since our data, as well as other studies, have demonstrated that subadult black bears are generally more tolerant of human activities. Closer examination of the data revealed that dens closest to trails were all natal dens. Dens of barren females and females accompanied only by yearlings were found much further from human occupied trails than those of females with newborn cubs (mean of 514 vs. 281 meters). Natal dens were significantly closer ($P<0.05$) while other adult females selected dens at distances similar to those for subadult study animals.

Our data indicate most black bears select for winter dens in remote areas further from human activities such as alpine ski and snowmobile trails. Females accompanied by newborn cubs, however, were often found in dens near winter recreational trails despite being more wary of other areas of concentrated human activity such as roads and houses. We hypothesize that this is due to bears initially selecting dens in late fall prior to the intense winter use of these recreational trails. Upon the arrival of winter recreationists, most bears likely seek alternate dens which are further from human disturbances while maternal females remain at their original den site rather than risk activity which might influence cub survival. We did not document incidents of collared bears abandoning den sites near recreational trails, although indirect evidence of this occurring exists. On at least four occasion during the study, lone bears were sighted traversing ski trails on Stratton Mountain in mid-winter.

The two females who selected dens and birthed cubs adjacent to ski trails were successful in protecting their cubs and leaving their dens at time periods similar to other bear families who had dens remote from human activities. Their success was likely in part due to the fact that their dens were near ski trails with southern exposures and were, as a result, avoided by skiers during late March once the snow had disappeared from the trail and the dens were exposed. We expected that additional disturbance from researchers would increase the likelihood of one particular mother abandoning her den and cubs and therefore chose not to conduct an otherwise routine changing of her collar at the den site that year. As with all dens checked during the Study, there was no fidelity shown toward these natal dens or others located further from anthropogenic disturbances.

Bear dens have been reported at other ski resorts. During spring skiing conditions at the nearby Maple Valley Ski Area in 1993, officials closed a ski trail after skiers reported seeing a female black bear with two newborn cubs in a den next to the trail. The local game warden monitored the den and reported that the early trail closure was successful in allowing the sow and her cubs to remain at the den for another three weeks until well after the ski area closed for the season.

Nuisance Behavior

Nationwide, black bears cause damage to a wide variety of agricultural and natural resources, and may pose a threat to human health and safety (Calvert et al. 1992). Interactions between humans and bears, and reports of damage from bears increase in years of natural food shortages (Rogers 1987, Elowe and Dodge 1989, Jonker et al. 1998). Obtaining adequate nutrition during these years can be difficult and may affect bear reproduction and survival (Schooley 1990). McLauglin et al. (1994), studying black bears in Maine, documented that a population dependent primarily on beechnut production had smaller body sizes and produced fewer young than a population that had access to agricultural crops as well as beechnuts. In separate studies, Rogers (1987) and McLean (1991) both noted that bears supplementing their diets with garbage had earlier ages of first reproduction and greater litter sizes than “wild” bears. In western Massachusetts, McDonald (1998) reported that bears feeding in cornfields were more apt to gain weight than bears feeding on natural foods even in years of hard mast abundance. Although viewed as a loss to farmers, feeding on corn benefits bears. McDonald reported that most Massachusetts bears have access to corn fields and that, because of this, the physical condition and reproductive performance of his study animals was unaffected by mast abundance unlike most populations studied elsewhere in North America.

Incidents of black bears displaying nuisance behavior within the Study Area were fewer than those reported in other areas of the country. Although cornfields were not available within the Study Area, six male study animals traveled outside of the Stratton Mountain Study Area in late summer to forage in fields of feed corn. Even though damage to corn crops was confirmed, there were no complaints or damage reimbursement claims received from the affected farmers. One large study animal was killed at the edge of a cornfield by licensed hunters during the regulated bear hunting season, while the remaining bears retumed to the Study Area by mid-fall of each year shortly after the corn crops were harvested. In one instance, a collared male bear left his home range on the Green Mountain National Forest to feed on corn in the town of Shaftsbury during two of the four years that his movements were monitored. These migrations both occurred in years of natural (food other than feed corn or commercial birdseed) food shortages (VTFWD unpublished hard mast data). Bears that have adapted this foraging strategy were in noticeably better physical condition when checked in their dens. They did not exhibit the drastic weight losses experienced by most bears within the Study Area following years of low mast production.

Other agricultural damage was linked primarily to one young male bear who roamed through the towns of Londonderry, Peru, and Winhall south of State Highway 11 in an area heavily fragmented by roads and houses. During the 1½ years that his movements were monitored, he did not display a normal aversion to human residences but instead, damaged bee hives, fed on human garbage, disrupted backyard barbecues, and mauled a dairy cow. His weight, when checked at his winter den as a 3-year old, like that of the other bears feeding on corn, was higher than the weight of those that fed exclusively on wild foods.

Only one female was linked to crop depredations. Her home range was centered on the southeast slope of Stratton Mountain where we monitored her movements for five years without any indication of her displaying nuisance behavior. During the food poor years of 1992 and 1995, however, she abandoned her home range and moved to within a few of miles of the Connecticut River in the Town of Westminster where she fed on apples in a commercial orchard until the first snowstorm of each year when she returned to den within her home range. The orchard owner was tolerant of her presence as he believed she was feeding at night after his employees and the public had left the orchard and that she fed exclusively on apples already on the ground. He reported no damage to his trees despite her feeding in the orchard for more than two months at a time.

In two different instances, yearling study animals were observed feeding on natural foods adjacent to houses and the Stratton Resort golf course. Eventually, each attempted to enter garbage dumpsters but were reported to have obtained no food before being chased off. One of these two bears was taken by a hunter the following hunting season and the other, a female, was monitored for three additional years, including one year of natural food shortage, without again displaying nuisance tendencies.

In sharp contrast to the Stratton Resort, the communities associated with mountain resorts south of the Study Area suffer from chronic nuisance bear problems. One restaurant in the town of West Dover annually attracts bears to its open dumpster and grease disposal container. The owners failed to follow recommendations to bear-proof their facility and instead appeared to enjoy the notoriety of their restaurant being a bear attraction. Several bears, including a sow and one of her two cubs, were killed after being struck on the highway in front of the restaurant. Another large male was destroyed behind the facility by a local game warden after becoming food conditioned and habituated to humans to the extent that he was believed to be a possible human safety risk. Nearby in the town of Wilmington, refuse management is a continuing problem. At one extensive mountain-side subdivision, consisting of approximately one thousand housing units, garbage is stored in individual containers easily accessible to bears. In addition to the many reports of people intentionally feeding bears, bird feeders and garbage containers are routinely raided in both communities by bears displaying different levels of food conditioning and habituation to people.

DISCUSSION

By pooling large sets of telemetry location data, certain trends of avoidance behavior were identified. Analysis of the telemetry data for radio-collared black bears suggested that, in general, southern Vermont bears avoid concentrations of houses and roads and are seldom found within 200 meters of them with some individual bears avoiding these developments out to 600 meters. The data also revealed, however, that bears avoid houses and roads to varying degrees depending on their sex and age. For example, subadult bears, still learning the inherent dangers of automobiles and people, were the least wary of houses and roads and were, consequently, the least likely to exhibit avoidance behavior. Roads and houses were also found to be avoided to varying degrees depending on their proximity to preferred food sources and on the particular human activity associated with the individual development. On several occasions, for example, bears were located within 200 meters of houses which were immediately adjacent to sources of jack-in-the-pulpit, apples, blueberries and choke cherries. Likewise, some Class 4 gravel roads, which bears were typically the least likely to avoid, were found to be avoided more than others, possibly due to these roads being used as hunting routes by houndsmen in pursuit of black bears.

Results from this study support the Vermont Fish and Wildlife Department’s mitigation guidelines (VTFWD 1992) for indirect impacts which are intended to protect a buffer zone of one-quarter to one-half mile from essential black bear habitat. In most cases, a one-quarter mile buffer would be adequate, with less being sufficient for protecting minor road crossing areas as most currently used road crossing sites in southern Vermont already have houses within that distance. Data from Wolfsons’ work (1992) with bear-clawed beech stands, however, indicates that a buffer of one-half mile may not be adequate to fully protect a beech stand receiving intensive bear use. He examined several beech stands which appeared to have been used heavily by bears in the past, but to have not been used as fall habitat during the recent time period when human developments had been built nearby. We suggest that bears feeding in hard mast stands in the fall may be more sensitive to disturbance from humans than when feeding in these habitats in other seasons. One possible explanation for this seasonal habitat abandonment is that beech stands, especially mature ones, are comparatively open hardwood forests generally lacking dense concealment cover. This lack of concealment cover is further compounded by the fact that bears utilize beech stands during the fall and early spring just after or prior to full leaf out thereby reducing cover even more. Wolfson's research suggests that bear-clawed beech stands may require the largest protective buffer of any black bear habitats. We recommend that hard mast stands receiving intensive use by black bears be protected from new roads and houses by a half mile buffer unless terrain features allow for less. Other types of human activities proposed near these stands that might be less intrusive should be considered on a case-by-case basis for possible smaller protective buffers.

Roads with heavy automobile traffic, mesh fences, open landscapes, extended lengths of steel guardrails, and clustered houses are barriers to bear movement while roads with fewer of these associated developments are semi-permeable barriers. Black bears negotiate the dangers associated with crossing roads by crossing when traffic is least heavy and by selecting sites with specific features involving terrain, food, concealment cover, and the absence of obstacles preventing them from making a rapid crossing. All crossing areas are forested on both sides of the road and usually include riparian corridors with dense understory vegetation such as wetland shrubs and small conifers. Good crossing sites, especially those located within regionally important movement corridors, are limited and are becoming increasingly degraded by highway widening, the proliferation of continuous lengths of steel guardrails, and by sprawling residential and commercial development. Road crossing sites, particularly those within movement corridors utilized by large numbers of bears, are essential for maintaining connectivity between large blocks of habitat and different subpopulations. Black bears select certain features for most crossing sites thereby affording conservation agencies easier identification, ranking and management of these important habitat features. Conservation strategies should include identifying these sites and establishing an importance ranking which reflects upon the road type, whether or not the crossing is within a travel corridor and of how unique the crossing is within a given area. This could be accomplished by ranking them by road type (Class 1-4), with Class 1 and 2 paved roads being the most important and then by designating them as being type "A" or "B", with A crossings being the most important and worthy of protection and management. Type B crossings would be minor crossings requiring less protection such as with just simple vegetation and guardrail management by the town or State highway departments. With this system, Class 1A crossings, such as the Route 100 crossing in Stratton, the Route 7 Exit 3 crossing in Sunderland, and the two crossings at the junction of Routes 30 and 11, would be top priorities for permanent protection and for developing long range management plans. Protecting as many crossing sites within a given corridor is probably prudent. Foreman and Codron (1986) in their classic book on landscape ecology advocated for conserving and managing as many as possible; "single crossings within a large corridor can be managed to enhance the movement of black bears, but crossing sites within smaller corridors that function as a series of interconnected links and loops as a network, provides a more efficient migratory system since alternative pathways are present."

Guard rails and mesh fences along roadsides within crossing areas were avoided by black bears except in areas with gaps parallel to each other on opposite sides of the road. On several occasions, radio-marked bears avoided guard rails when attempting to cross 2-lane roads, and traveled parallel to the roadway until reaching areas without guard rails, and crossed at that point. Our data on guardrails is limited to mostly anecdotal observations, but we believe that the guard rails presented not only a physical obstacle at a point where bears were reluctant to cross anyway, but that they also interfered with the bears' ability to watch for oncoming traffic —

guard rails are normally at eye-height to adult black bears. In planning for guardrail openings we recommend that they be at least 20 meters in width, that they be located in areas of dense vegetation, and that the area not have other obstacles to travel such as steep banks, rock ledges, or fields. Where guardrails occur on both sides of the highway the gaps should parallel each other. At a minimum, long lengths of roadside guard rails within black bear travel corridors should have a 20 meter opening for every 100 meters of guard rail length.

Black bears crossed low-traffic volume roads more frequently than roads with higher traffic volumes. Only male bears were documented crossing Class 1 highways with automobile traffic volumes exceeding 1400 per day. Highways which limit the immigration and emigration of female bears may be reducing the genetic diversity of bear populations in Vermont as well as potentially decreasing the species ability to recolonize some areas of the state. Ongoing research at the University of Vermont into the genetic characteristics of black bears may provide insight into whether or not habitat fragmentation is restricting their genetic diversity in different regions of the state.

During poor food years, black bears travel greater distances and cross paved roads more than in other years. Male study animals, in general, crossed paved roads at a higher rate than females. Both these behaviors are seen in the Vermont Fish and Wildlife Department incidental mortality data with more bears being killed on highways during years of food shortage; and the overall ratio of males to females being killed is approximately 2:1 (VTFWD unpublished bear data).

Several locations within the Study Area were identified as being occupied by only transient male bears. Although these areas were large enough to contain a female's home range, they were highly fragmented by roads which would deny females access to seasonally-abundant foods in years of food shortages. Furthermore, these areas may not have included remote, undeveloped tracts of land large enough to provide security areas which would meet the home range spatial requirements of female black bears. The loss of these productive habitats to female bears translates to an overall reduction in the reproductive capacity of the population and is, at least in part, a consequence of high road and housing densities near resort communities – a growing trend in the Vermont landscape.

Black bears are intelligent and adaptable as evidenced by most having home ranges that include roads and houses which they either avoid, or learn how to approach undetected utilizing dense concealment cover and by being more active during crepuscular and nocturnal time periods when people are less apt to see them.

Remoteness is an important attribute of quality black bear habitat. Even those bears with home ranges containing roads and houses incorporated adjacent areas of unfragmented forest habitat into their ranges to serve as refugia or security areas. Clusters of houses and areas with high road densities are avoided by bears and thereby function as barriers to their movements. Black bears traveling through areas of anthropogenic disturbances, such as crossing a highway with frequent residential developments, typically travel along riparian corridors and cross roads where they bisect streams with dense riparian cover. Highways can be modified to facilitate safe passage for black bears (and other animal species) by protecting wide riparian buffers, planting conifers in roadside fields, creating gaps in guard rails, and by installing extended bridges that have dryland on both sides of the stream channel in lieu of narrow box culverts which force most wildlife to cross over the roadway. A key to maintaining healthy populations of black bears throughout southern Vermont may lie in protecting linkages between the remaining large blocks of forested habitats and providing safe routes of travel across highways. It is clear from the results of this study and other studies on black bears that human-dominated landscapes will not sustain bear populations without access to source habitat (i.e., large unfragmented blocks of forestland).

Our results indicate that the human activities may displace bears from their dens. Examples of den abandonment specifically associated with alpine ski and snowmachine trails were lacking and so their impacts are inconclusive. Other human activities have been documented causing den abandonment. Many bear researchers have reported den abandonment due to investigator disturbance (LeCount 1983; Manville 1983; Mack 1988; Kolenosky and Strathearn 1987; Hellgren and Vaughan 1991; Goodrich and Berger 1994). We experienced several den abandonments as a result of this study but were able to minimize disturbance by conducting den visits during periods of deep snow when the bears were most secure, by approaching the den quietly from downwind, by re-covering the den prior to the full awakening of the bear from tranquilization, and by choosing not to visit some dens if the conditions were not favorable. We also observed five instances involving collared bears where other types of human activities caused den abandonment. Three occurred in late November during the opening weekend of the deer hunting season soon after bears had entered their dens. These abandonments occurred presumably as a result of deer hunters traversing the forest near their dens. Two other study animals were displaced from their dens in December, apparently as a result of a combination of snowmachine activity and trained beagles chasing snowshoe hares in thick conifer cover near the bear's dens.

Our data support the belief that it is the human activity associated with a trail and not just the physical presence of the trail itself which influences black bear avoidance of some areas within their home ranges. We suggest that the presence of only natal dens in close proximity to recreational trails, as documented in this study, indicates that many other bears, unencumbered by pregnancy and newborn cubs, may initially select dens adjacent to these areas but are displaced from their dens once the winter recreational activity begins. This belief is supported by Mack (1988) who documented three female bears relocating to new dens after being disturbed by humans. Two of the three were females with yearlings, and the other was barren. No natal dens were abandoned.

Areas with broken terrain, containing large trees and of a remote nature, provide the most secure denning areas for black bears. Because females have small home ranges and always select dens within their own home ranges, consideration for denning sites is an additional reason why resort planners and wildlife managers should plan for areas of large blocks of undisturbed habitat adjacent to mountain resorts. Dens that are discovered near recreation trails will probably be natal dens that can be protected by temporarily closing segments of trails closest to the den site.

Throughout the two resort communities of West Dover and Wilmington south of Stratton, bears routinely feed on garbage from collection sites, raid back yard bird feeders, and exhibit a general fearlessness of people. These communities differ from the Stratton Mountain Resort community, which has comparatively few bear problems, in that they sprawl over a much larger area of fragmented bear habitat, buildings are not clustered, garbage is easily accessible to bears, and hunting generally does not occur in the areas surrounding each development. At the Stratton Resort, bears are wary and are seldom seen by people, buildings are primarily in dense clusters, and boundaries between the residential/commercial developments and forested bear habitat are more distinct. Regulated hunting, including hunting with the use of hounds, is permitted on the forests surrounding the Stratton Resort and undoubtedly adds to the overall wariness of the bear population. Although some bears in the Stratton area are annually removed through regulated hunting, these losses are fewer than that for other communities where bears habituated to humans are killed on highways and removed as nuisance animals. It appears that black bears living in multiple-use and highly fragmented habitats have frequent opportunities to become conditioned to human foods. Human-bear conflicts are less frequent in communities where bears have become negatively conditioned to humans. This negative conditioning however, comes at a cost to the bear population as it then requires larger buffers from human development which in turn results in the loss of foraging opportunities and a net loss of effective habitat. Management programs should be directed at discouraging food-conditioning and habituation and should encourage public education about black bears. Human developments in bear range should consider the needs of bears and should be directed away from their preferred habitats. Allowing only low levels of human use in essential bear habitats will not only help reduce human-bear conflicts, but will ensure viable populations of free-ranging wild bears through the future.

CHAPTER 7

SUMMARY OF BLACK BEAR USE OF THE STRATTON MOUNTAIN RESORT

Historically, ski areas probably caused fewer problems for black bears as they were operated only seasonally during the time of year when bears were hibernating. Conceivably, the cleared ski trails even created habitat diversity which provided important spring and early summer feeding areas for bears just coming out of hibernation. In recent years, however, most ski areas have evolved into corporate-owned, mountain resorts characterized by extensive second home development, ski villages, and increased recreational use during the spring, summer, and fall seasons as well as during the winter ski season. Some ski areas now record more recreational visitors prior to the onset of the traditional ski season than during the ski season itself. Along with this expansion of the ski industry, the potential for wildlife habitat destruction became eminent particularly for black bears whose preferred habitats are within the remote, mountainous regions of the State where most ski areas are located. In response to the rapid growth of the ski industry the Vermont Fish and Wildlife Department initiated its efforts to conserve black bear habitat.

Wildlife managers estimate there to be over 3500 black bears living within the forested habitats of approximately 47 percent of the State's land area. They believe bears in Vermont are more wary and reclusive than those in other more urban states such as Pennsylvania and Massachusetts as Vermont bears are seldom observed and relatively few are involved in nuisance situations. One probable explanation for this behavior in Vermont is the long hound training and hunting seasons for bears. Regulated hunting with the use of hounds is a traditional rural Vermont activity and serves to promote and maintain a wild and wary bear population. Hunted populations of bears are conditioned to avoid areas of human activities such as resorts and residential developments. Although a reduction in wariness on the part of bears may allow some bears to occupy more marginal habitats, an increase in wariness leads to a reduction in undesirable interactions with humans (State of Vermont, 1997). Even in the absence of a bear hunting season using hounds, bears are reclusive in nature and would likely tend to avoid the type of concentrated resort development that is characteristic today. Because of this avoidance behavior, wildlife managers in Vermont have routinely used a displacement distance, or buffer, of up to one-half mile in their efforts to conserve areas of known critical habitat.

Stratton Mountain Resort And Black Bears

The Stratton Mountain Resort has been a leader in the ski resort industry in working closely with state wildlife officials to conserve and manage wildlife habitat. Their interest in bears is also reflected in the place names of ski trails, roads, and facilities located throughout the resort and by a black bear on the resort logo.

The Stratton Mountain Resort Black Bear Study was initiated in 1989 in response to the resort's proposal to nearly double the size of their facilities. Early funding was provided by the Resort while the research was done by independent researchers and the Vermont Fish and Wildlife Department. The development proposal focused on the expansion of the resort community to the south side of the mountain in an area now known as the "Sunbowl" – an area documented as being actively used by black bears. The proposal included new ski trail and an expanded lift system, an additional 18-hole golf course, approximately 500 new housing units, sport shooting courses, mountain biking programs, and a variety of other recreational activities. In addition to these proposed impacts, another corporation proposed to build a large residential community nearby to the southeast of the Stratton Resort.

The Department believed that the planned developments of the Stratton Mountain Resort represented an opportunity to further investigate the impacts of resort development on black bears. A study was conceived with the overall goal of developing specific recommendations to guide future resort planning in a manner which protected black bear resources. Quantifying necessary protective buffers were identified as being a key objective of the study.

A variety of research methods were used or developed to document bear activity and behavior within the Stratton Mountain Resort Study Area. Scent station surveys, inventorying and quantifying claw marks on beech trees, monitoring bear activity through the use of trained bear hounds, conducting survey transects to document the occurrence of bear foods, recording bear sign and bear road crossings, and documenting collisions with cars were all methods incorporated into the study. Most importantly though, bears were captured and equipped with radio collars which allowed individual bears to be monitored through hand-held telemetry on a daily basis.

The Study Area is mostly within northern hardwood forests composed primarily of maple, beech, yellow birch, and ash trees. Most resort facilities are clustered on the north side of the mountain while the south side remains relatively undeveloped (Figure 7.1).   Mature beech trees are a major component of the forest and are distributed in large numbers throughout the resort area. Many beech trees throughout the resort show evidence of past bear climbing activity by the residual claw marks (bark scars) left on the tree trunks. Prior to the initial development of the resort, the entire area was utilized by black bears as confirmed by the old, black claw marks on beech trees found within the main village and residential areas. Evidence of recent scarring, occurring within the past seven years, was used in conjunction with year-round telemetry locations of black bears to determine current levels of bear use within different areas of the resort and to provide insight into bear behavior and tolerance of human activities.

During May 1990 through November 1995, 48 radio-collared bears were located a total of 3,155 times in order to evaluate patterns in their seasonal distributions. Bear distribution was analyzed in relation to various landscape features (four road types, seasonal and year-round occupied houses, ski trail areas, and forested areas) and to an equal number of randomly generated location points in order to develop a descriptive model using proximity analysis. Comparison of the percent occurrence of telemetry locations and random location points allowed us to determine black bear avoidance distances of the various landscape features.

Figure 7.1 Map of Stratton Moutain Resort

Bear Use and Avoidance of Resort Facilities and Activities

Results from the different methods used in documenting bear activity allowed us to make observations regarding bear sensitivity to human recreational activities and resort facilities. Telemetry locations were compared to an equal number of randomly distributed points in order to evaluate bear use levels within different areas (A-F) of the Study Area having various degrees of human development and recreational use (Figure 7.2). Areas A-C were areas of resort development and centers of recreational activities while areas D-F were comparatively free of human developments and concentrated recreational activities and contained large blocks of forest that were known to be bear habitat unfragmented by roads. Area G was an undeveloped area where we received poor telemetry signal reception resulting in it not being evaluated in our final analysis.

In general, the resort village, condominiums, housing units, parking lots, sewage plant, maintenance buildings, tennis courts, and golf course which constituted analysis area "A", were all avoided by bears. This area was distinguished from other areas by having high levels of human activity, large forest openings containing human developments, and little natural concealment cover. Quantifying the displacement distance, or buffer, preferred by black bears was complicated by the fact that not all bears reacted equally to human developments and activities. Monitoring bears with telemetry transmitters revealed no use within the areas of human activity, but on seven occasions during the spring and summer seasons, bears were located foraging in strips of woods in close proximity to the village. Some food plants preferred by bears were more abundant (see Chapter 5) in areas of rich soils which characterize most of the resort village and golf course thereby attracting less wary bears. Bears venturing near these areas usually did so to feed on jewelweed and jack-in-the-pulpit roots during the night hours concealed by darkness and returned to more remote areas by dawn. No bears, however, were observed within area "A" during the fall (Table 7.1) despite it containing large numbers of mature beech trees, some of which displayed old claw marks indicating a history of climbing activity previous to resort development.

Area "B" encompassed the mountain face overlooking the resort village. Although relatively forested, it was heavily fragmented by ski trails, roads, and lift lines. The trails and service roads within this area received intensive recreational use year-round. During the spring through fall months, it was used by hikers, joggers, tourists riding the gondola, students training at the Mountain School, mountain bikers, horseback riding enthusiasts, sightseers, construction workers, and by resort maintenance workers. Although bears were occasionally seen in this area, most apparently avoided it or passed through quickly during the spring and fall seasons. Overall, the area was used much less than expected. During the summer, however, a few collared bears were documented using the large forest strips within the ski trail network to forage on jack-in-the-pulpit roots occurring primarily at lower elevations on the mountain. Bears foraging in this area were active mostly at night and usually left the area before dawn. Within this area, the greatest use by bears was within two large forested blocks nearest the edge of the trail network and south of the North Brookwood Development where jack-in-the-pulpit plants were common.

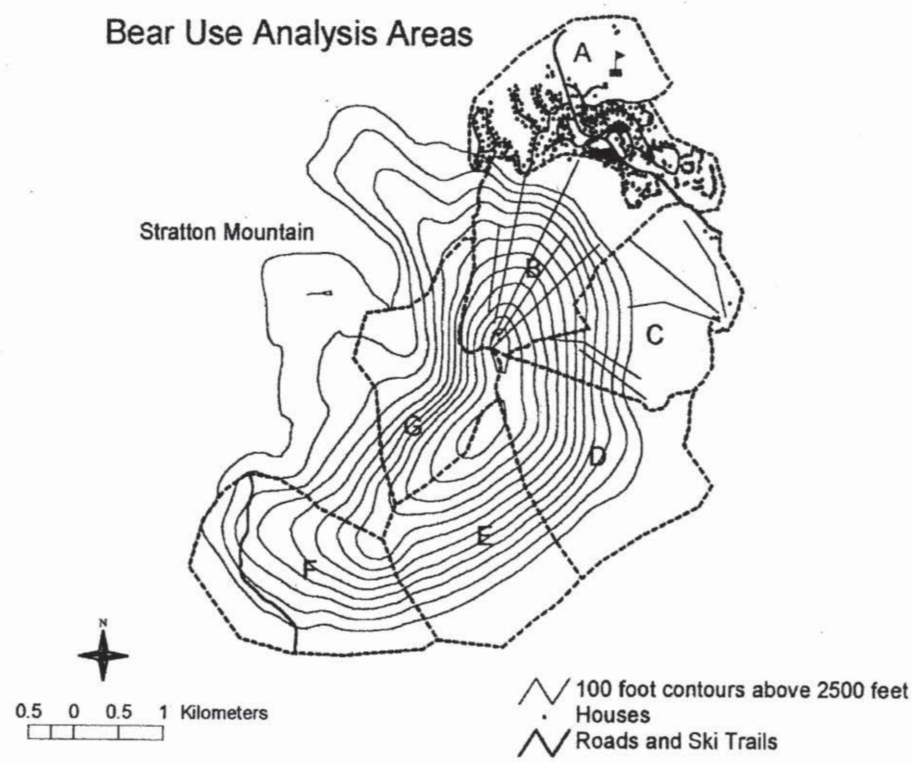

Figure 7.2. Map of Stratton Mountain showing analysis areas used to compare levels of study animal use between areas with varying levels of human activity. Areas A-C contain development and recreational areas of the resort while areas D-F are relatively unfragmented by human development. Area G was not used in the final analysis due to poor telemetry location accuracy.

Table 7.1. Seasonal location points of study animals compared with expected number of random points in relation to six areas of varying levels of human development and activity on Stratton Mountain, Vermont during 1990-1995.

	Number of Locations				
			Observed by Season		
Analysis Area	Expected	Observed	Spring	Summer	Fall
Village & Golf Course (A)	52	7	3	4	0
Intensive Recreation (B)	48	24	3	20	1
Low Recreation (C)	47	78	17	49	12
Remote Forested (D)	53	59	9	23	27
Remote Forested (E)	50	64	8	24	32
Remote Forested (F)	54	72	19	15	38

Areas A and B, containing the highest concentrations of human development and the largest number of recreationists, were used least by radio-collared bears. This trend was especially evident during the fall when no bears were documented using Area A and only one bear was recorded in Area B. Although portions of these two areas showed up within the mapped home ranges of a few of the study animals, this was due to the home range software extrapolating their ranges and does not necessarily represent actual home range use. A secondary test of the telemetry results was conducted by examining the proportion of mature beech trees which had been climbed by black bears in each of the analysis areas. Results from this investigation duplicated that of the telemetry monitoring results in revealing that bears had not used the area of the resort village (Area A), nor the forested habitat surrounding the golf course (Area B), at all in the past seven years (Figure 7.3). Only the oldest trees showed signs of having been climbed by bears, and most of the scars that were evident appeared to have been made at least twenty-five years ago. Similarly, a few trees in Area B were found to have been climbed in recent years but, proportionally, represented less than ten percent of the use documented on beech trees located outside of the trail network in the Kidder Brook drainage.

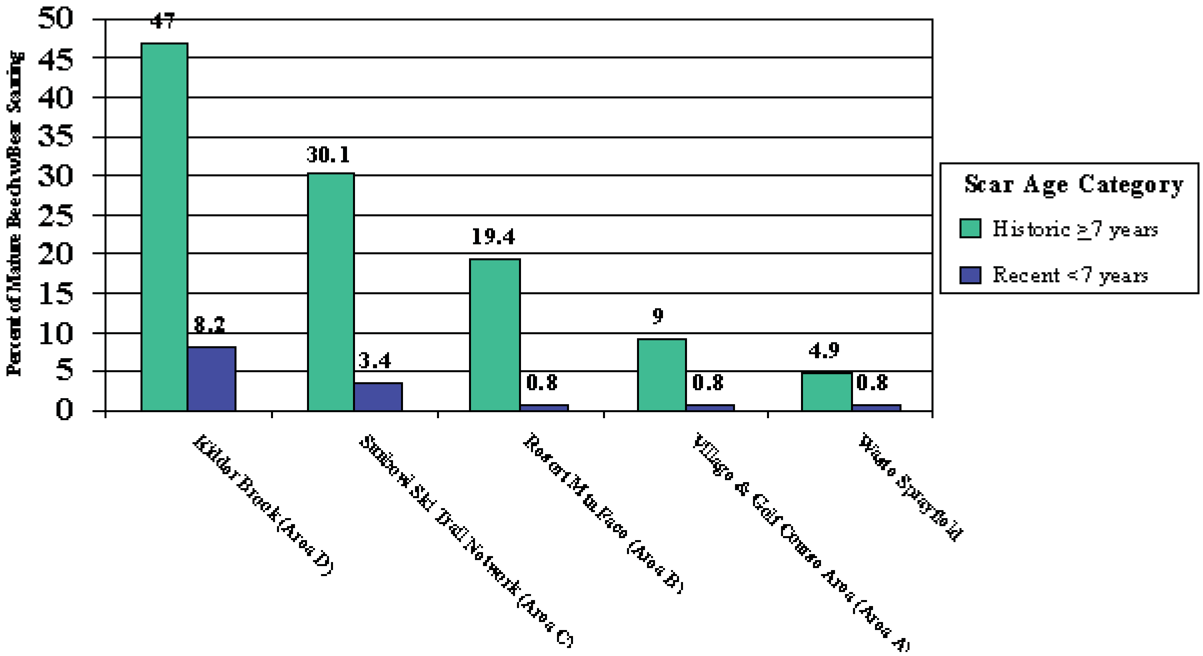

Figure 7.3. Percent of mature beech trees having historical and recent bear claw scarring by designated area of the Stratton Mountain Resort. For this analysis, 2,304 beech trees were examined in February, 1997.

The Sunbowl region of the resort (Area C) contained a network of ski trails but had no residential structures and received only light recreational use. Surprisingly, bears were found within this area in the spring and summer more than in any other area including the more remote control areas (D-F). They were observed primarily feeding on succulent plants on the edges of the ski trails with heaviest use occurring on the outermost trails, on benches and depressions within trails, and on narrow trails bisecting blocks of forest between the larger ski trails. At any given time during the five years that collared bear movements were monitored, at least one bear could be located in, or adjacent to, the Sunbowl area during the spring and summer. It comprised a large portion of one adult female's (#28) home range and was used at times by at least seventeen other collared bears including several of her own offspring. Although many bears used the Sunbowl it apparently did not function as good security cover. On several occasions we noted that when study animals encountered people in the area they moved rapidly across Kidder Brook and into more remote areas less fragmented by roads and trails.

Using data gathered from monitoring collared animals, we concluded that bears used the Sunbowl area more in the summer than the three, forested comparison areas (D-F), but that use within the Sunbowl dropped off significantly in the fall while use in Areas D-F increased substantially. These results were further reinforced by looking at the percentage of mature beech trees having been climbed in recent years in the Sunbowl and Kidder Brook areas. Although bears had climbed beech trees in the Sunbowl area at a much higher rate than in other areas of the mountain containing ski trails, bears had climbed beech trees in the Kidder Brook area at more than twice the rate (8.2 vs. 3.4%) than they had in the Sunbowl area. This supports the findings of Wolfson's graduate work (1992) which suggested that remote beech stands are used more intensively by black bears in Vermont than those located closer to sources of human activity.

We documented black bears using the Sunbowl area at a greater level during the summer than in any other region of Stratton Mountain. Other wildlife species such as moose, bobcat, fisher, white-tailed deer, and turkeys were also observed in the area. Intensive use of the Sunbowl by wildlife was in large part due to Stratton Resort's management of the area which intentionally minimizes human activity in the Sunbowl during the summer to benefit wildlife. Although horseback and mountain bike riding is a significant component of the summer recreational program, the resort uses spatial, temporal, and behavioral restrictions to minimize the impacts recreationists have on wildlife. Both horseback and mountain bike riding is limited to specific trails and time periods designed to leave the outermost trail area available as productive habitat for bears and other wildlife (Figure 7.4). Additionally, these two activities are not allowed during the early morning and evening hours when bears and other wildlife species are the most active. These restrictions serve to reduce the overall incompatible nature of these human activities with bear use of the area. Other types of recreation which would either remove large blocks of habitat, such as golf courses and tennis courts, or would generate loud noises, and thereby possibly displacing bears, such as sporting clay courses and ATV riding, are not allowed within this area of the resort. The timing of snowmaking operations are also restricted in the fall such that the outermost trails are not subjected to snowguns until well after the bears are hibernating.

Other resort management activities which, in the case of the Stratton Ski Resort, actually benefit bears are associated with the waste water sprayfield and with powerlines. Bears, as well as deer and turkeys, are attracted to the 42-acre hardwood forest located adjacent to the resort village where, after treatment at the sewage facility, waste water is dispensed through a grid system of pipes and nozzles. Benefitting from the supplemental water and nutrients, two key bear foods, jewelweed and jack-in-the-pulpit plants, flourish in this man-made environment at levels much greater than those found elsewhere in the region. Restrictive signing, coupled with the natural aversion of humans to enter areas where waste products are disposed, allows bears and other wildlife to forage relatively undisturbed in this excellent feeding habitat. Our examination of this sprayfield, and of others statewide, revealed that the amount of bear use was highly variable and depended on a number of considerations including its proximity to larger blocks of forest and human activities, initial site preparation, forest and soil type chosen for the field, fencing, volume sprayed, and level and type of management. We concluded that waste sprayfields can be located, developed and managed in such a way as to be important wildlife habitat.

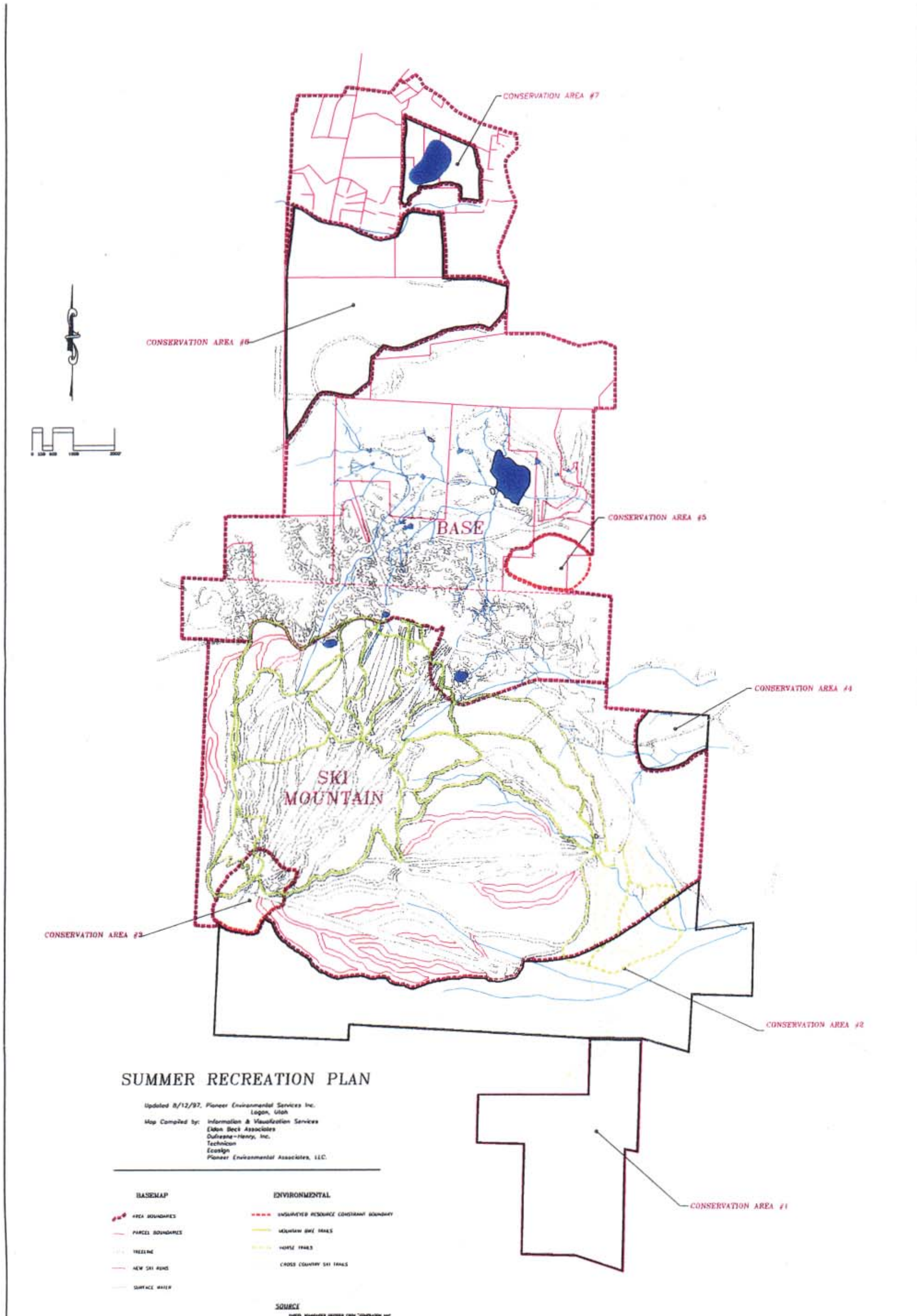

Figure 7.4. Map of ski trails showing trails used by mountain bikes (solid green) and by horses (green dots).

The powerline that enters Stratton Resort from the north also provides seasonally important habitat for black bears. Raspberries and black berries, which are important late summer foods, grow in profusion within many areas of the powerline corridor. Although not intentionally managed for bears, the power company's efforts to control shrub and tree growth within the powerline right-of-way corridor in effect maintains a linear berry field through the resort and U.S. Forest Service lands and attracts large numbers of bears and other wildlife species when the berries are available. During one year, however, herbicides were sprayed prior to the berries ripening. The timing and methods of vegetation control should be coordinated so that berries are available to wildlife annually. Potential exists for improving black bear habitat throughout its range by simply coordinating brush control programs with power companies to allow for maximum berry production.

Snowmaking ponds can also provide feeding habitat for black bears. At the Stratton Resort most ponds were not used by bears because they were located within residential developments or golf courses, lacked sufficient concealment cover, or were surrounded by barrier fencing. The North Brookwood pond, however, received some use by bears. This pond was located at the far northwest side of the development adjacent to a large block of unfragmented forest, had fencing limited to the side adjacent to the houses, had a visual barrier of trees between the houses and the pond, and had tall vegetation growing close to the waters edge on the side facing the forest. Its outflow was directed into the forest thereby creating a wetland containing important food plants which allowed bears to use the area during the spring and summer months when growth of these plants and of deciduous tree leaves provided dense concealment cover.

The Stratton Mountain Resort Master Plan

Concurrent with the black bear study, the Stratton Corporation, developed a Resort Master Plan as a requirement of the Act 250 permitting process. Concern about the potential impacts the proposed resort development on regional wildlife resources led to the creation of a Wildlife Habitat Management Plan (1997) as part of the Master Plan. This comprehensive management plan outlined the steps the Corporation would take to mitigate possible habitat losses and proposed various wildlife habitat enhancement measures. When completed, the Plan demonstrated a commitment by the Resort for wildlife far greater than that required through the permitting process. As part of their mitigation measures, seven different conservation areas containing a total of 2,219 acres, nearly one-half of their mountain property, were established (Figure 7.5). Management of the Conservation Areas focuses on minimizing conflict between humans and wildlife while preserving the functions of the area as a developed ski resort. Future Resort growth is intended to be sensitive to the needs of the resident black bears.

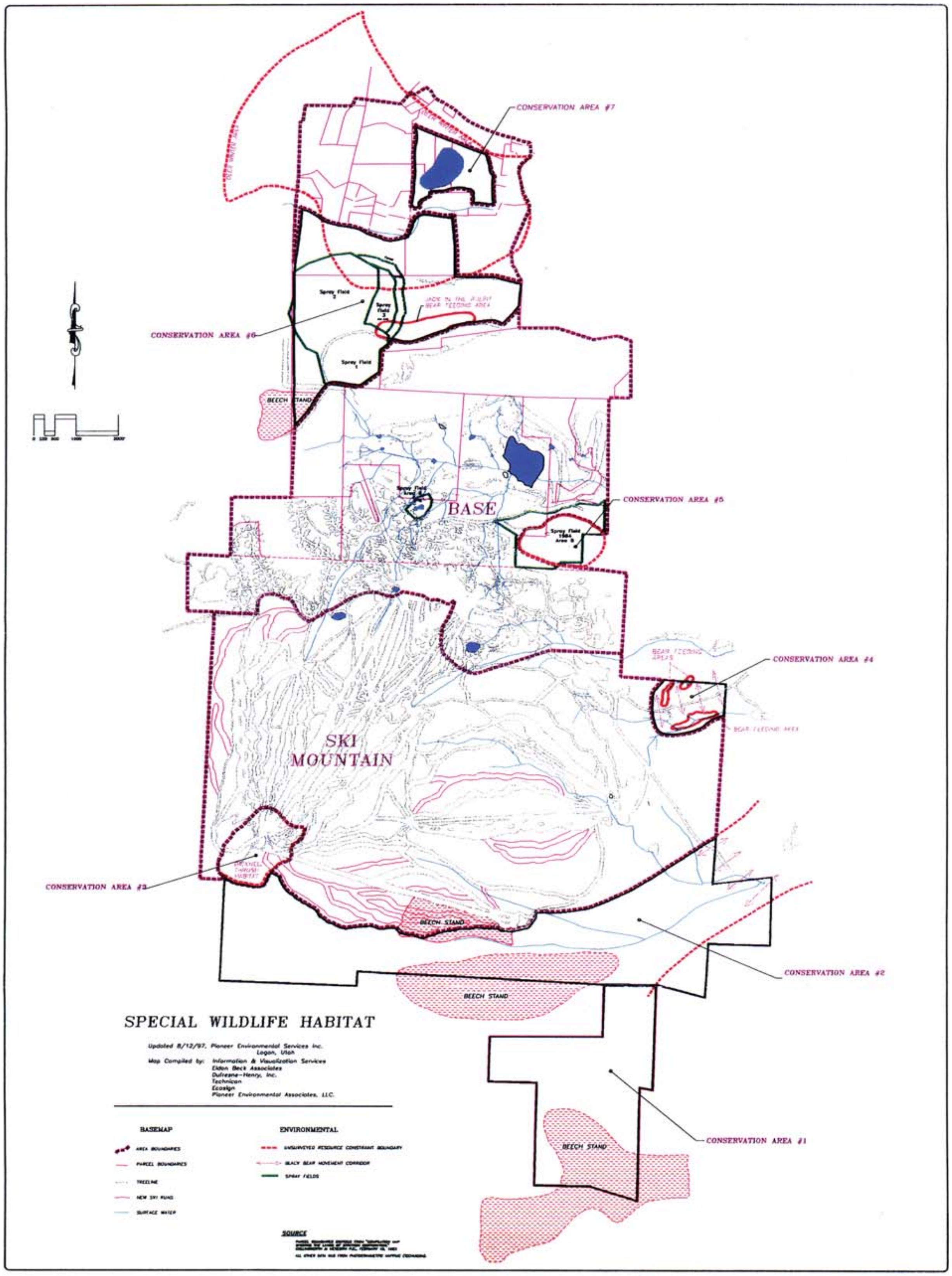

Figure 7.5. Special wildlife habitat and conservation areas of Stratton Mountain.

Five of the Conservation Areas (1, 2, 4, 5 and 6) totaling 1434 acres are to be managed primarily for black bears with the objective of protecting key feeding areas, travel corridors, and security areas. Within these areas, there will be limited resort development and only compatible recreational activities. Two of these areas (967 acres total), containing an important bear travel corridor and several beech stands, will be conserved with an easement which prohibits development and allows only educational, forestry, wildlife habitat management, and limited recreational activities. The remaining three areas will receive special management thereby allowing bears to use the old and new waste water spray fields (Conservation areas 5 & 6) as feeding areas, and to protect a wetland complex and travel corridor (Conservation Area 4). Only limited development will be allowed within these three Conservation Areas. Conservation Area 6, a new waste water sprayfield, will be designed and developed in a manner which improves the area as black bear habitat.

Future Concerns — Monitoring, Education and Research Needs

The Stratton Mountain Black Bear Study was originally intended to include an investigation of bear responses to human developments before, during, and after construction of the resort's facilities in the Sunbowl area. For a variety of reasons, the Resort's development permits were not issued until after the study was completed thereby limiting us to interpreting black bear distribution and behavior in relation to only existing developments. The information gathered was useful, however, in helping develop bear management recommendations for the Wildlife Habitat Management Plan for the Stratton Resort. Although we believe the information to be valid, it is based solely on data collected prior to the expansion of the Resort. An effort should be made to conduct some level of monitoring to assess changes in habitat use after the resort's additional development plans come to fruition. One concern is that since the study was completed, horseback and mountain bike riding have increased in some areas of the Sunbowl to to the extent that the forest trails are worn down to bare ground. During the time period of the Study, these old logging roads and cross-country ski trails were used only lightly by bicycles and horses and produced many of the delicate herbaceous plants eaten by bears. These recreational activities, although somewhat compatible with bear use of the area when maintained at low and infrequent levels, may have negative impacts when increased.

Other concerns involve how increased densities of new houses constructed on private land within the Sage Hill Corridor and on lands north of the Sunbowl Lodge have impacted bear use of the area. Another concern is whether or not the newly-completed wastewater sprayfield is increasing the amount of food available to the bears and if bear use of the area has actually increased. Managers of black bear habitat would also benefit from additional research conducted on several key food plants. Jack-in-the-pulpit, jewelweed, and the sedge *Carex gynandra* are all important to bears and are influenced greatly by timber harvest and forest development activities. Guidelines should be developed for managing hardwood forests for the production of these plant species.

The Stratton Resort has an excellent program of garbage disposal that prevents local bears from becoming conditioned to human foods. Relatively few complaints of nuisance black bear behavior were received throughout the duration of this study. In recent years, however, bears have begun causing problems in most of the surrounding communities which contain bear habitat. Wildlife managers attribute this to an increase in the number of people living within bear habitat, an expanding bear population, fewer areas where hunting is allowed, and to a growing trend of people feeding birds year-round. Bird seed is more attractive to bears than most of the natural foods available to them during the spring and summer. Unfortunately, once bears have overcome their initial wariness of people, eating back yard birdseed usually leads to them searching for other human-related foods and causing property damage. Eventually there is an increased probability that they will be killed as a nuisance animal or struck by an automobile while crossing roads. To prevent increases in nuisance activity Stratton Resort managers will need to continue to work cooperatively with state wildlife biologists in developing educational programs for Resort visitors which will address this growing problem. Regulated hunting of black bears should continue to be allowed as it helps in maintaining a wary, free-ranging population of bears that is less likely to become conditioned to foraging for garbage and bird seed within the Resort's residential areas.

APPENDICES

APPENDIX A

Capture data and fate of 52 black bears monitored as part of the Stratton Mountain Black Bear Study, 1989-1996. Weights are in pounds.

ID. No.	Sex	Tag #'s	Capture Method[a]	Date 1st Captured	Date Birth	Capture Weight	Age When Killed	Date Killed	Mortality Type
1	M	226/227	S	6/14/89	1987	110	2 3/4	/89	hunter
2	F	274/275	H	6/17/89	1980	110	10 3/4	10/90	hunter
3	M	229/228	H	6/24/89	1987	75	2 3/4	/89	hunter
4	F	230/231	H	7/4/89	1986	100	—	—	—
5	F	285/293	H	7/4/89	1987	37	—	—	—
6	M	251/203	H	7/4/89	1984	250	5 3/4	/89	hunter
7	M	233/232	H	7/9/89	1986	120	3 3/4	/89	hunter
8	M	49/44	H	7/14/89	1981	190	9	6/90	natural
9	M	266/267	H	7/15/89	1981	140	—	—	—
10	F	50/30	H	7/16/89	1989	52	—	—	—
11	M	236/234	S	7/17/89	1986	130	—	—	—
12	M	239/238	H	7/22/89	1976	240	15 3/4	11/1/91	hunter
13	F	273/272	H	7/23/89	1987	80	—	—	lost
14	F	67/68	H	4/27/90	1989	58	2 3/4	11/91	hunter
15	F	10/11	H	4/27/90	1984	125	12 3/4	11/96	hunter
16	M	59/60	H	7/7/90	1980	220	15	6/95	natural
17	M	51/52	H	9/29/90	1990	42	—	—	—
18	F	53/54	H	9/29/90	1990	33	3/4	11/90	natural
19	F	61/62	D	3/12/91	1980	108	13 3/4	9/28/93	hunter
20	M	65/66	H	4/28/91	1989	82	3 3/4	11/15/92	hunter
21	M	74/75	S	5/4/91	1985	145	—	8/94	car
22	M	71/72	H	5/26/91	1989	98	—	—	—
23	M	69/70	H	6/13/91	1986	165	—	—	—
24	M	55/73	S	6/13/91	1990	38	—	—	—
25	F	24/22	H	7/6/91	1987	90	—	—	—
26	M	2/3	H	7/12/91	1990	40	3 3/4	11/13/93	hunter
27	M	8/4	H	7/21/91	1987	145	5 3/4	11/92	hunter
28	F	5/6	H	7/25/91	1981	125	—	—	—

Appendix A. (Continued)

ID. No.	Sex	Tag #'s	Capture Method[a]	Date 1st Captured	Date Birth	Capture Weight	Age When Killed	Date Killed	Mortality Type
29	M	13/14	H	8/17/91	1987	135	5 3/4	11/14/92	hunter
30	F	7/16	H	8/29/91	1990	45	1 1/2	8/91	capture
31	M	—	—	—	—	—	—	killed in MA	hunter (MA)
32	M	36/21	S	6/20/92	1990	130	3 3/4	11/13/93	hunter
33	M	12/15	S	6/30/92	1990	153	2 3/4	11/15/92	hunter
34	F	17/18	H	8/15/92	1977	123	15 3/4	9/16/92	hunter
35	M	35/27	H	8/22/92	1985	175	—	—	drop
36	M	28/29	H	9/7/92	Adult	120	—	—	drop 10/92
37	M	31/32	H	10/11/92	1991	100	—	—	—
38	F	33/34	H	10/20/92	1990	110	4 3/4	10/30/94	hunter
39	M	37/38	D	3/16/93	1992	35	—	6/94	natural - bear
40	M	39/40	S	6/11/93	1987	150	—	—	drop
41	F	105/-	H	6/13/93	1978	105	—	—	—
42	M	41/43	S	6/25/93	1991	120	3 3/4	9/12/94	hunter
43	M	44/45	H	6/26/93	1988	150	—	—	—
44	M	48/49	H	7/3/93	1989	145	4 3/4	10/21/93	hunter
45	F	46/47	H	7/11/93	1992	50	1 3/4	—	capture
46	M	50/-	H	7/25/93	Adult	200	—	9/18/93	hunter
47	M	none	H	8/7/93	—	125	—	—	drop
48	F	101/102	H	8/21/93	1992	65	—	—	—
49	M	103/104	S	6/10/94	1991	125	—	—	drop
50	F	174/175	H	7/24/94	1986	115	—	—	—
51	M	107/108	H	8/7/94	1993	60	4 3/4	10/17/97	hunter
52	F	none	D	2/23/95	2/94	40	–	–	–

[a] *D = den; H = hounds; S = snare*

Annual home range size for black bears in southern Vermont using Adaptive Kernel (95% contour) and Minimum Convex Polygon (100% contour) methods, 1990-1995. Autocorrelated points have been deleted. The prefix S indicates subadults.

Females	Year	N	Adaptive Kernel (95%) Area (ha)	Minimum Convex Polygon (100%) Area (ha)
F2	1990	30 (34*)	7260 (8583*)	4694 (4712*)
F5	1991	44	3504	2601
F10	1993	49	1819	1448
SF13	1990	58	2829	2580
F13	1991	104	4929	4799
F13	1992	69	4515	3457
SF14	1990	42	5337	4944
SF14	1991	87	7743	7500
F15	1990	43	4612	3558
F15	1991	63	3901	4295
F15	1992	59 (64*)	6522 (12720*)	6941 (7731*)
F15	1993	57 (59*)	4945 (5920*)	3808 (5038*)
F15	1994	67	2879	2602
F15	1995	55	3042	2280
F19	1991	70	1242	1108
F19	1992	61	1786	1741
F19	1993	46	2270	1846
F25	1991	38	2013	1648
F28	1991	51	3356	2892
F28	1993	62	3672	3939
F28	1994	82	3442	4508
F28	1995	41	5499**	4173**
F41	1994	39	3772	3366
F41	1995	52	3980	3669
SF48	1994	78	2536	2224
SF48	1995	51 (55*)	5263(6728*)	4600 (4988)
F50	1994	36	2033	1405
F50	1995	56	2213	2085
SF52	1995	35	2022	1425

Males	Year	N	Adaptive Kernel (95%) Area (ha)	Minimum Convex Polygon (100%) Size (ha)
M9	1991	54	8394	9847
M9	1994	38	11680	8262
M11	1990	41	14220	10180
M11	1991	42	12920	10140
M11	1992	49	39150	19736
M11	1994	41	26730	19220
M12	1991	30	23450	15480
M16	1991	31	18550	17390
M16	1994	41	7869	6117
M21	1991	65	15760	13520
SM22	1992	52	30200	8133
M23	1991	46	13590	9959
SM26	1991	71	4137	4102
M27	1992	40	5795	4190
SM32	1992	33	22140	13180
M43	1994	32	7481	9887
SM51	1994	32	1600	1159

** Home range calculation includes remote fall forage area.*

*** Home range calculation does not include fall dispersal area.*

APPENDIX C

Notes on bear foods found in the Stratton Mountain Study Area.

Common Names	**Scientific Names**	**Notes on Feeding and Abundance**
Aspen, quaking	*Populus tremuloides*	Leaves and buds eaten in spring months.
Ants	Various	Adults and larvae important sources of protein in late summer and early fall.
Beech, American	*Fagus grandifolia*	Nuts eaten as available; may be most important as early spring food, sprouts eaten throughout spring and early summer.
Blackberries	*Rubus* spp.	Important as late summer and fall food; probably most important berry species in Vermont.
Cattails	*Typha* spp.	Occurs in wetlands; young shoots and roots eaten.
Currants	*Ribes* spp.	Fruits eaten but not very important diet item as seldom occurs in large patches.
Dandelion	*Taraxacum officinale*	Eaten spring and summer where available; grows in openings which most bears avoid.
Clovers	*Trifolium* spp.	Eaten spring and summer where available; sometimes grows on skid roads, log landings and ski trails.
Dogwoods	*Cornus* spp.	Fruits eaten when available; probably not a very important diet item.
Cherries	*Prunus* spp.	Fruits eaten in late summer and fall in the years when they are abundant; black cherry may be primary fall food in years when other mast species fail.
Cranberries	*Vaccinium* spp.	Fruits eaten in late summer and fall but generally not abundant.

Continued...

Appendix C. *(continued)*

Common Names	**Scientific Names**	**Notes on Feeding and Abundance**
Elder, European red	*Sambucus racemosa*	Fruit eaten in late summer and fall but generally not abundant.
Fern, cinnamon	*Osmunda cinnamomae*	Reported as bear food in some areas but no observed feeding in Vermont.
Grapes, wild	*Vitis* spp.	Late summer and fall food but occurs primarily around low elevation openings outside of most bear range such as around corn fields.
Jack-in-the-pulpit	*Arisaema triphyllum*	Corm (and sometimes leaves and fruit) eaten in summer; may be the most important summer food source for Vermont bears, about 14% protein; found throughout Vermont at elevations below 2000' in mature hardwoods with moist, deep soils and occasionally in wetlands.
Deer and moose	*Odocoileus virginianus* and *Alces alces*, respectively	Droppings eaten by bears as found; the microflora and fauna contained in the feces is perhaps used by bears to aid in digesting plant fiber.
Horsetails	*Equisetum* spp.	Reported as an important food item in some areas of N. America but not documented in Vermont .
Oaks	*Quercus* spp.	Acorns are an important fall food when available; unfortunately oak is found infrequently in Vermont bear range as it is more common at lower elevations of southern part of state; northern Vermont has few oak.
Bunchberry and partridgeberry	*Cornus canadensis* and *Mitchella repens*, respectively	Eaten but not plentiful enough to be an important diet item.
Pine and Spruce	*Pinus* spp. and *Picea* spp., respectively	Buds eaten for a very short time period after leaving dens; new growth high in sugars.

Continued...

Appendix C. *(continued)*

Common Names	**Scientific Names**	**Notes on Feeding and Abundance**
Sphagnum mosses	*Sphagnum* spp.	Bears have been observed digging it up but for unknown reasons; it has been suggested that they eat the moss or are looking for invertebrates.
Raspberries	*Rubus* spp.	Important in some areas; grows profusely in some powerline R.O.W.s in bear range.
Shadbushes	*Amalanchier* spp.	Early ripening berries eaten by bears when found, but not usually in large quantities.
Amphibians	Various	No documented feeding on amphibians in New England; habituated bears in New Hampshire refused toads and frogs.
Strawberry, wild	*Fragaria ovalis*	Too small and of limited availability in forests to be very important.
Sarsaparilla	*Aralia nudicaulis*	Ripe berries readily eaten in years when in good supply (one year in last six years).
Leaves	Various	Leaves of many shrub and tree species eaten in spring especially from fallen trees which supply readily accessible leaves; early budding species such as aspen and red maple are the most important.
Cow parsnip	*Heracleum lanotum*	Flowers most important in some states, however, not documented in Vermont.
Skunk cabbage	*Symplocarpus foedidus*	Most important spring food in Massachusetts and part of New Hampshire but almost nonexistent in Vermont bear range.

Continued...

Appendix C. *(continued)*

Common Names	**Scientific Names**	**Notes on Feeding and Abundance**
Tall nodding sedge	*Carex gynandra*	Only sedge observed to be fed on by Vermont bears; heavily fed on in April and early May as it is sometimes the only food available if overwintering beech nuts and acorns are absent; this species is found in disturbed forested areas such as skid roads and log landings.
Hazelnut, beaked	*Corylus cornuta*	Nuts eaten but not plentiful in southern Vermont bear range.
Squawroot, American	*Conopholis americana*	Most important food in many southeastern states but not found in much of Vermont bear range.
Hickories	*Carya* spp.	Nuts eaten where available but not plentiful in Vermont bear range.
Snowberries	*Symphoricarpos* spp.	Fruits eaten but not plentiful in Vermont bear range.
Lettuce	*Lactuca* spp.	Roots and leaves eaten.
Apples, wild	*Malus* spp.	Fruits readily eaten especially after first snowfall; often damages tree during feeding.
Corn	Cultivated	Important food resource in some areas of the state; in years of natural food shortage, bears may travel large distances to feed in corn fields adjacent to forest cover.
Mountain-ash, American	*Sorbus americana*	Berries ripen late in year but seldom in large quantities; in 1994 they were plentiful and were observed to be an important diet item.
Jewelweed	*Impatiens capensis*	Major summer and early fall food item especially in years of drought; grows well on wet, disturbed forested sites.

Continued...

Appendix C. *(continued)*

Common Names	**Scientific Names**	**Notes on Feeding and Abundance**
Deer	*Odocoileus virginianus*	The hair and hooves of fawns is frequently found in June bear droppings.
Beaver	*Castor canadensis*	Some bears, primarily large males, seek out and tear apart beaver lodges in spring and early summer.
Marshmarigold	*Caltha palustris*	Stalk, leaves and flowers eaten in spring.
Maple, red	Acer rubrum	Seeds eaten during summer in years that they are plentiful.
Leek	*Allium schoenoprasum*	Presumed to be a late summer food but not documented in Vermont.
Sweetcicely	*Osmorhiza claytonii*	Eaten in some areas of the country but not documented in Vermont.
Grasses	Various	Eaten when young and succulent in areas available to bears.
Winterberry	*Ilex verticillata*	Reported as a diet item of bears in Virginia and the Carolinas.
Woodsorrels	*Oxalis* spp.	Leaves eaten sporadically in summer.
Hobblebush	*Viburnum alnifolium*	Berries seldom plentiful but eaten when found.

APPENDIX D

“Bear.apr” maps were created by Aaron Hurst in July and August 2001 and are not considered survey accurate. This is the third generation project with the original project created by Shawn Powell in the early 1990s. The second project was created by Phoebe Kilham in the middle to late 1990s. Original data projected in NAD 1927 and use for the first two projects. The current project uses parts of the original data, some reprojected in NAD 1983, in conjunction with additional new data and updated data sources. Bear points are based on telemetry data.

Data sources include VCGI and UVM Spatial Analysis Lab, both in Burlington, Vermont for most geographic coverage. Other sources include USGS maps coverage quadrangle tile 0504, and infrared photography 4196-173. Photo digitized at Lyndon State College by John DeLeo.

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