

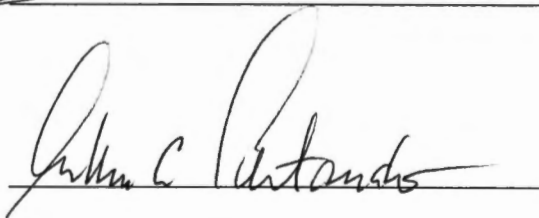
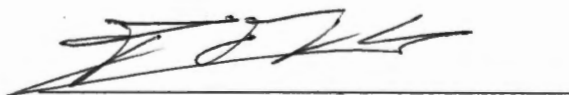
To the Graduate Council:

I am submitting herewith a thesis written by Meghan M. Carr entitled "Home ranges and habitat use of Asiatic black bears in Nagano Prefecture, Japan." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

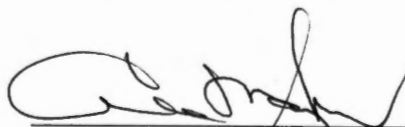


Michael R. Pelton, Major Professor

We have read this thesis and
recommend its acceptance:



Accepted for the Council:



Interim Vice Provost and
Dean of the Graduate School

**HOME RANGES AND HABITAT USE OF
ASIATIC BLACK BEARS IN NAGANO PREFECTURE, JAPAN**

A Thesis

Presented for the

Master of Science Degree

University of Tennessee, Knoxville

Meghan M. Carr

May 2001

AO-VET-MEL

Thesis

2001
.C38

DEDICATION

This thesis is dedicated to my family.

Michael LeGrand Carr

Jeanne Gray Carr

Kevin Gray Carr

Everything good in my life is somehow due in part to their love and support.

I want to celebrate the intellectual, financial, and emotional support of my parents for my incredible education and so much more of my development. They also have given me freedom to reach for my dreams and experience wonders around the Earth. I already have achieved many of my dreams in 29 years and I give much of the credit to them.

My brother, you have “cursed” me with a very strong tie to Asia. I cannot imagine a better friend to not only meet on both sides of the “pond”, but also with whom to experience Asia. Here’s to many more adventures, Ludwig von Bubba Jones.

Mom...Dad...Kev, I love you.

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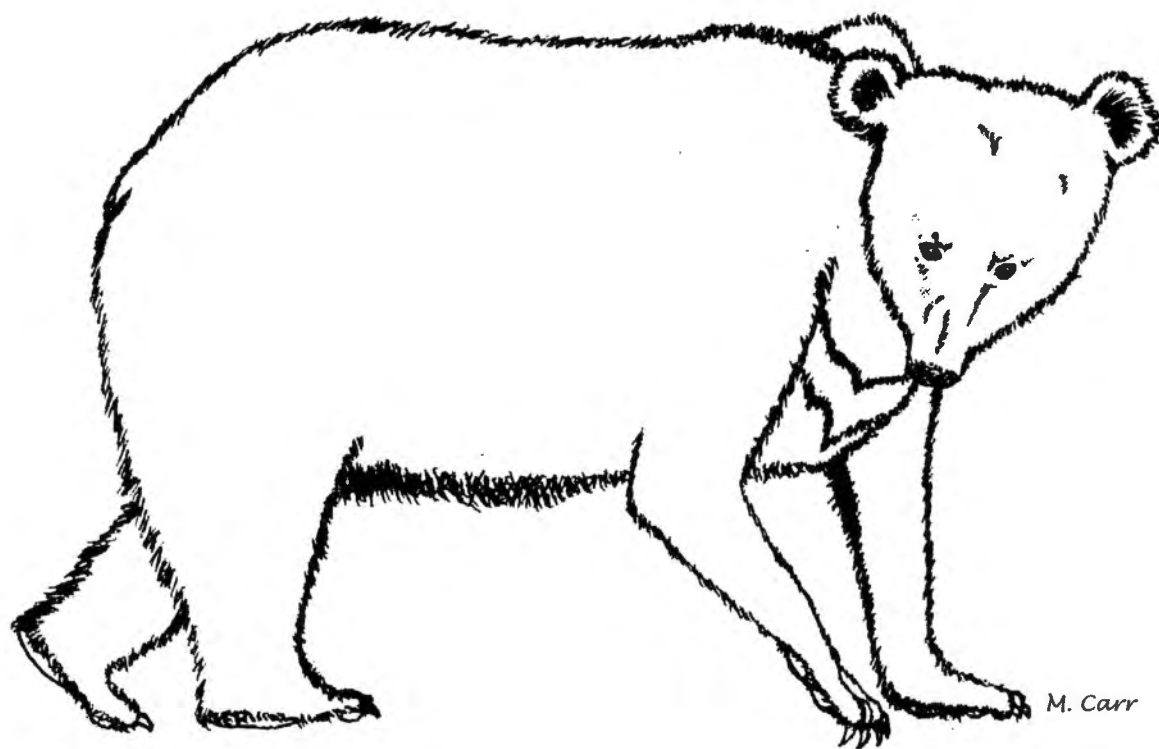
I want to send my appreciation to the other graduate students at the University of Tennessee. In particular, I want to thank Thomas Eason and Donny Martorello for suggestions on how to improve my research. I also want to give my regards to the 2 “oni” during my first semester – they know who they are. Thanks to Jay for mentoring me through being a Teaching Assistant. Jennifer Murrow, Steven Dobey, and Mark Boersen provided a lot of technical support during the last year. Jennifer was especially helpful with demonstrating GIS techniques. “Arigatou gozaimasu” to Jun Yoshizaki for translating, giving other “Japan” help, and being a friend.

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ABSTRACT

Japan may have >20% of the world's Asiatic black bears (*Ursus thibetanus*), but continuing local extinctions have resulted in an overall decrease of the Japanese subspecies (*U. t. japonicus*). This decrease is related to loss and fragmentation of habitat and liberal permit systems for depredation kills. Science-based management could mitigate much of the effects of these threats, but decisions usually are made without adequate ecological data. From 1997 to 1999, I studied bear habitat relationships in the central, mountainous region of Honshu, the main island of Japan. Bears were captured with barrel traps and fitted with radiocollars. I collected 1,479 locations and selected 507 locations of 13 bears for analysis. Home ranges averaged 18.7 km² by the minimum convex polygon method; 10.0 km² for females and 24.2 km² for males. The average home range sizes for the 95%, 75%, and 50% contours were 24.2 km² (SD = 15.1), 20.4 km² (SD = 7.4), and 8.4 km² (SD = 3.2), respectively. I used classification and regression tree analysis (CART) to determine the hierarchical structure of bear-habitat associations in a 154-km² study area. I generated random locations within the study area and compared habitat types with those of bear locations. Bears used oak and planted forests in the montane zone (<1,460 m) more than expected. Habitat use at this local scale seems mostly related to the distribution of food resources, such as hard mast in the natural oak forests and soft mast in the planted forests. I also applied a model of habitat use based on the Mahalanobis distance statistic to a 432-km² area. Areas with the greatest bear use were usually associated with deciduous forests, of which >95% had oaks as 1 of 2 dominant species. The model associated values for lower habitat quality with cut forests

that had poor regeneration. Cut areas that were regenerated through planting often had higher values in the model; these areas may be used for cover or for food resources, such as soft mast. Where bears included low-quality habitat in the core of their home ranges, they also had access to higher quality habitat. The results of this study indicate that different forestry management schemes influence bear habitat use. The most critical management needed to ensure the long-term viability of the Asiatic black bear population in Japan is the protection and promotion of oak-dominated forests in the montane zone.

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CHAPTER 1

INTRODUCTION

PROBLEM STATEMENT

World Status

Asiatic black bears (*Ursus thibetanus*) had a wide distribution that included Europe until the mid-Pleistocene (McLellan and Reiner 1994). The current distribution is still wide, but restricted to 4 regions from tropical to cool, temperate climates: 1) from Southeast Asia across China to Pakistan and Iran; 2) around the intersecting borders of North Korea, Russia, and China; 3) in Taiwan; and 4) on 2 islands of the Japanese archipelago (Fig. 1-1) (Gutleb 1998, Servheen et al. 1999).

Despite the extensive range of Asiatic black bears, less than 50,000 are estimated to exist worldwide, and no populations seem to be stable or increasing (Servheen 1990, Servheen et al. 1999). Threats to the species include poorly regulated harvests (Hazumi 1999), pet trade, lack of data, and habitat loss (Servheen et al. 1999).

Partially responsible for high harvests of bear populations is the threat from traditional Chinese medicine markets. Chinese and other Asian cultures (i.e., Japanese and Korean cultures) promote aphrodisiac, culinary, and curative properties of bear parts, particularly of bile as a cure for numerous infections, toxins, and skin, heart, and digestive disorders (Mills and Servheen 1994, Servheen et al. 1999). Viability of ursodeoxycholic acid (UDCA), the active ingredient, is supported by Western medical research. Western practitioners sometimes use UDCA to treat liver ailments, including

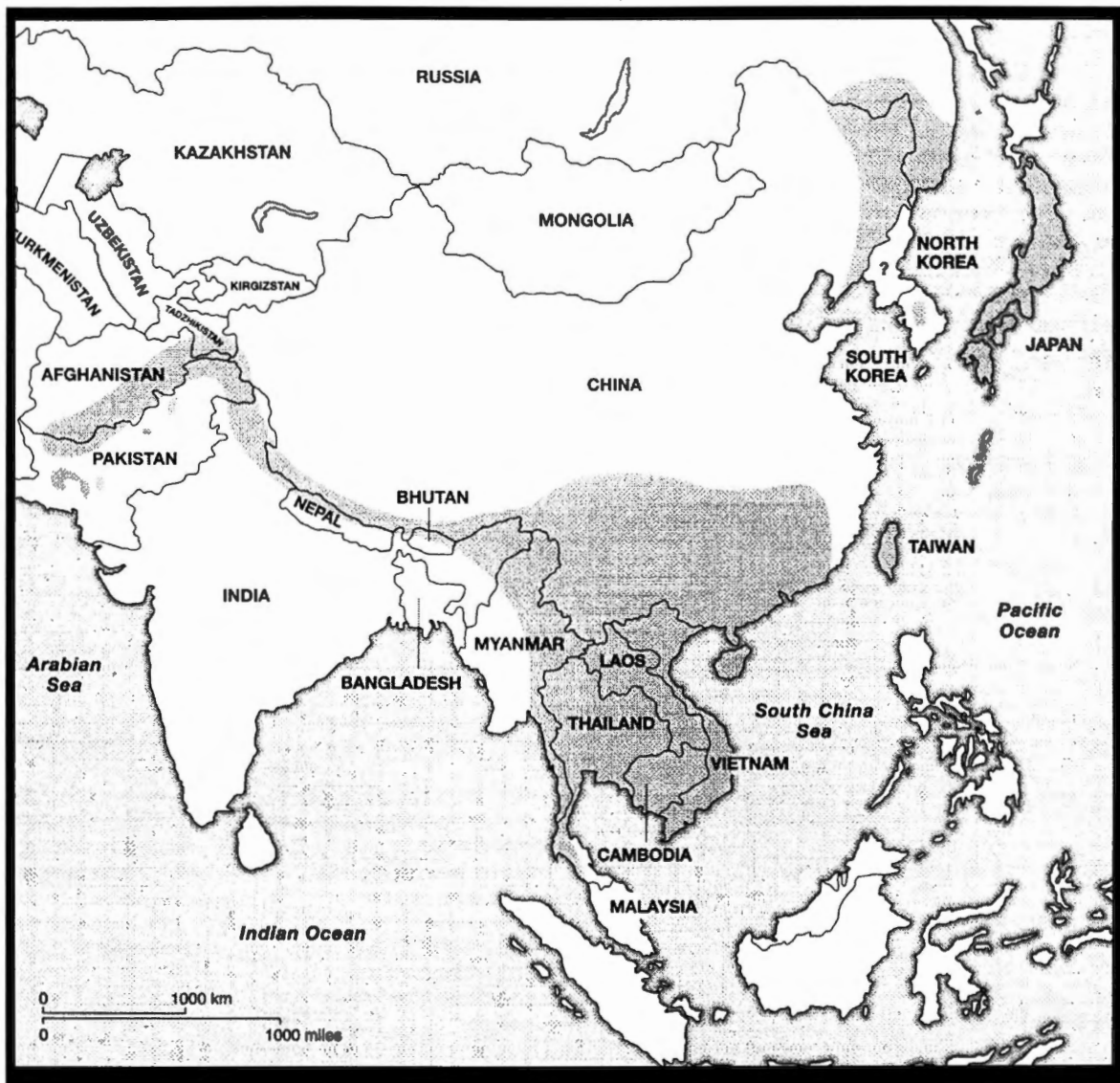


Fig. 1-1. World distribution of Asiatic black bears (dark gray). From Servheen et al. (1999).

gallstones. Synthesized UCDA is available, but many traditional Chinese medicine practitioners believe the natural product is superior (Mills and Servheen 1994).

Unless habitat loss and exploitation are controlled and mitigated, the future of the species is questionable (Servheen 1990, Hazumi 1999). To counteract effects of the medicine market on bear populations, legal protection and enforcement of existing laws, along with efforts to find alternatives or adaptations to bear farming (Fang 2000), need to be increased. Many authors have suggested that habitat protection and management need to be promoted to ameliorate all of these threats in the long-term (Ma and Li 1999, Sathyakumar 1999, Hazumi 1999, Chestin and Yudin 1999, Wang 1999, Sam 1999).

Status in Japan

A subspecies of Asiatic black bears, *U. t. japonicus*, is found in Japan. Males weigh an average of 70 kg versus 60 kg for females (Hazumi 1996); this is less than averages for other Asiatic black bear populations. Distributions of the Japanese and American black bear (*Ursus americanus*) populations are closely associated with mountainous areas. Similarities in the appearance and ecology of Asiatic and American black bears (Schaller et al. 1989; Reid et al. 1991; M. Pelton, University of Tennessee, personal communication) may be related to similar latitude (36°) and environments.

Japan has been recognized as having crucial leadership potential for wildlife conservation in Asia (Moll 1998: 23). Among countries where Asiatic black bears occur, Japan may have the highest potential for healthy bear populations. Compared with most other Asian countries, Japan had a stable economy and slowing rate of economic

development over the last 3 decades (Central Intelligence Agency 1998). Consequently, many Japanese have the luxury to think beyond their daily needs.

An estimated 10,000 to 15,000 bears inhabit Japan, but many black bear populations are decreasing. Although some populations may be stable, there have been numerous local extinctions. The population on Kyushû (Fig. 1-2) is now extirpated, along with many other populations in western Honshu and around Tokyo (Hazumi 1999). Currently, population size on the island of Shikoku is estimated to be <100 bears and decreasing (Hazumi 1994, Roy 1998).

Exterminations may be the most immediate threat to black bears in Japan. About 2,000 bears are lost each year because of nuisance killings and hunting. Based on a population estimate of 10,000–15,000 black bears, Huygens (1998) estimated that this annual kill represented approximately 7–10% of the Japanese bear population. Roy (1998) estimated a harvest of 10–20% of various local populations. Considering the lack of resources invested in data collection or enforcement of harvest limits (Sato et al. 1998), reported numbers may be conservative estimates (Hazumi 1999).

Long-term threats to black bear in Japan include habitat fragmentation and loss, poaching, and, indirectly, the limited scope of science-based wildlife management agencies and professionals (Hazumi 1994, Roy 1998, Hazumi 1999). The primary causes of habitat loss include timber harvests, residential area expansion, and road construction. Poaching mainly seems to be related to the traditional Chinese medicine market.

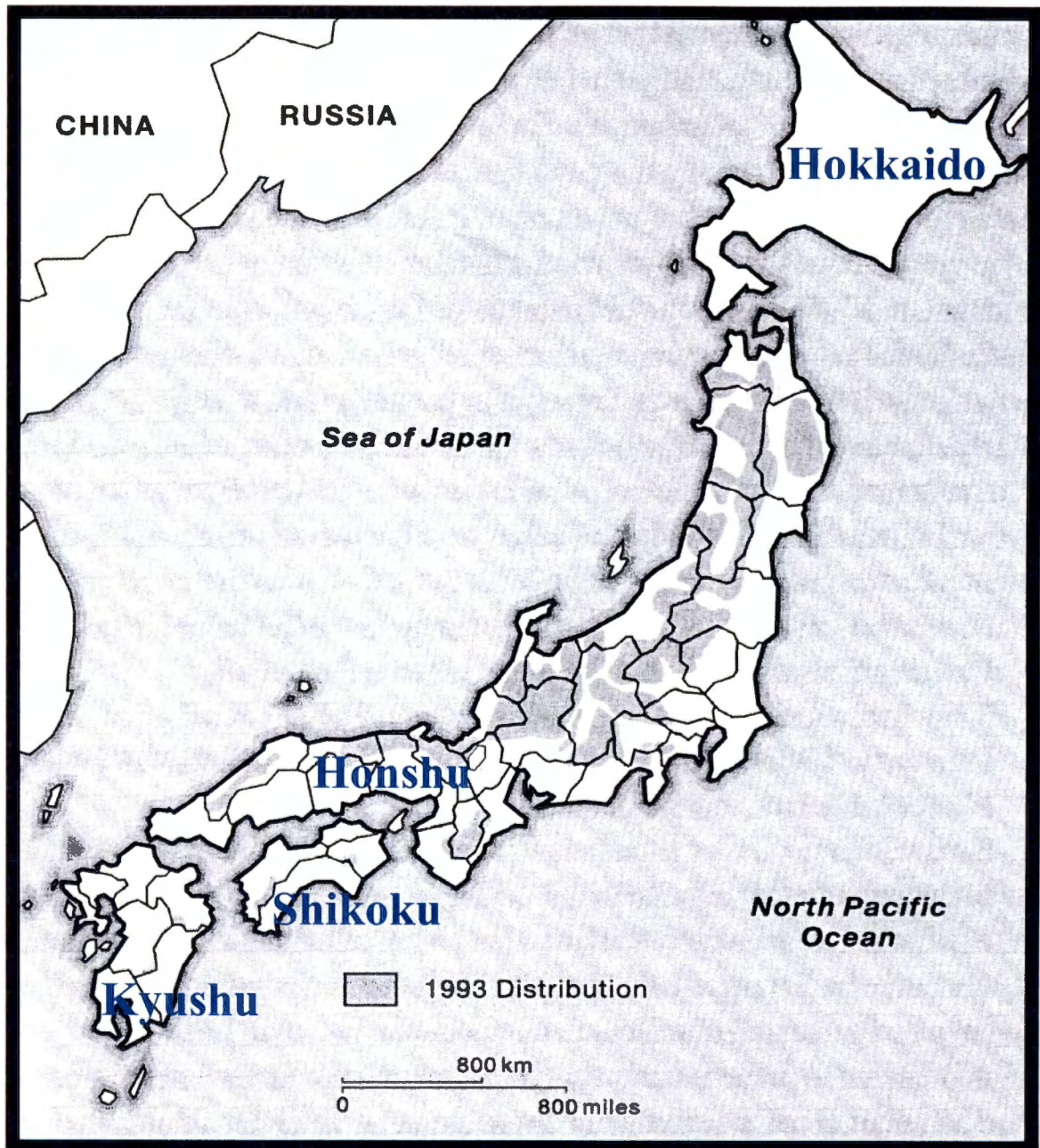


Fig. 1-2. Distribution of Asiatic black bears in Japan (modified from Servheen et al. 1999). Asiatic black bears are considered to be extirpated from Kyushû.

BACKGROUND AND JUSTIFICATION

Japan is an archipelago consisting of >4,800 islands and covers more than 20° latitude (from boreal to subtropical climates). Human density is high with >125 million people living in 374,744 km² (335 people/km²). However, because only 32% of the land area is livable and arable (Hazumi 1994), Japan continues to be a stronghold for Asiatic black bears with $\geq 20\%$ of the 50,000 bears worldwide. Although the mountainous topography affords some protection, it has not prevented extirpation of local bear populations or decrease of the population as a whole (Roy 1998, Hazumi 1999). Japan has designated relatively large areas as national parks or other protected areas (Oyadomari 1985), but limited resources often lead Japanese to choose economic benefits over conservation (Oyadomari 1985, Yamada 1990, Kellert 1991, Hazumi 1999).

Normally, foresters resolve wildlife conflicts at the village level (Huygens and Hayashi 1999). Even if local officials are sensitive to conservation issues, it is difficult for them to promote alternative techniques (Hazumi 1999, Huygens and Hayashi 1999) because local residents often prefer lethal methods (Azuma and Torii 1980, Watanabe 1980, Roy 1998, Hazumi 1999, Huygens and Hayashi 1999). A recent study disputed the effectiveness of exterminating bears to reduce damage costs (O. Huygens, Shinshū University, personal communication).

Without a wildlife agency proactively managing bears, research on Asiatic black bears in Japan has been limited. Radio telemetry research on Asiatic black bears in Japan started around 1969 (Kogawa 1971, Mizuno et al. 1972, Hazumi 1993). The Environmental Agency, the federal government division formed in 1971 to take

responsibility for environmental issues, increased support for large mammal projects in 1980 and this led to 3 principal bear projects (Hazumi et al. 1981, Nozaki and Mizuno 1983, Torii 1989). Another telemetry project was conducted in Akita Prefecture from 1981 to 1991 and provided greater understanding of breeding behavior and other ecological relationships (Hazumi 1993). My study was designed to expand on the knowledge gained from these earlier projects and more recent ones.

This study was developed in association with a larger project of the Shinshû Asiatic Black Bear Research Group, Matsumoto, Japan. This group aims to understand the ecology of the species and minimize losses due to nuisance exterminations in Nagano Prefecture. Understanding of spatial ecology and habitat use of Asiatic black bears must be improved to implement science-based management and protection for the species in Japan (Servheen 1990, Roy 1998, Hazumi 1999). Spatial ecology can be useful to measure important changes in habitat conditions.

OBJECTIVES

Particular objectives of my study were to:

- 1) describe home range characteristics of Asiatic black bears,
- 2) determine habitat use, and
- 3) determine habitat suitability within a larger study area.

CHAPTER 2

STUDY AREA

GEOGRAPHY AND TOPOGRAPHY

The study area was located in Nagano Prefecture (36°20'/137°48') in the central portion of Honshu, the main island of Japan (Fig. 2-1). The prefecture is 13,585 km². A majority of the land (64%) was privately owned. Eighty percent was mountainous and 78% was forested. Agricultural uses accounted for a significant portion of the remaining land use and the prefecture contained approximately 149,000 farms (Huygens 1998). The change in relief is extreme, often forming a distinct border between mountains and valleys, where human settlement is concentrated.

Research was conducted in the west-central section of Nagano Prefecture (Fig. 2-2). The study area was approximately 50 km south-southwest of Nagano City, site of the 1998 Winter Olympic Games, in the southeastern section of the Northern Japan Alps (Fig. 2-2).

Altitude in the study area ranges from approximately 700 m to 2,900 m. Drainages are composed of numerous smaller valleys, and access to many areas was difficult or impossible because of dense vegetation and steep terrain. Most of the research effort was concentrated in the Nakabusa, Karasu-gawa, and Shima-shima drainages. These areas covered approximately 220 km² (Fig. 2-1).

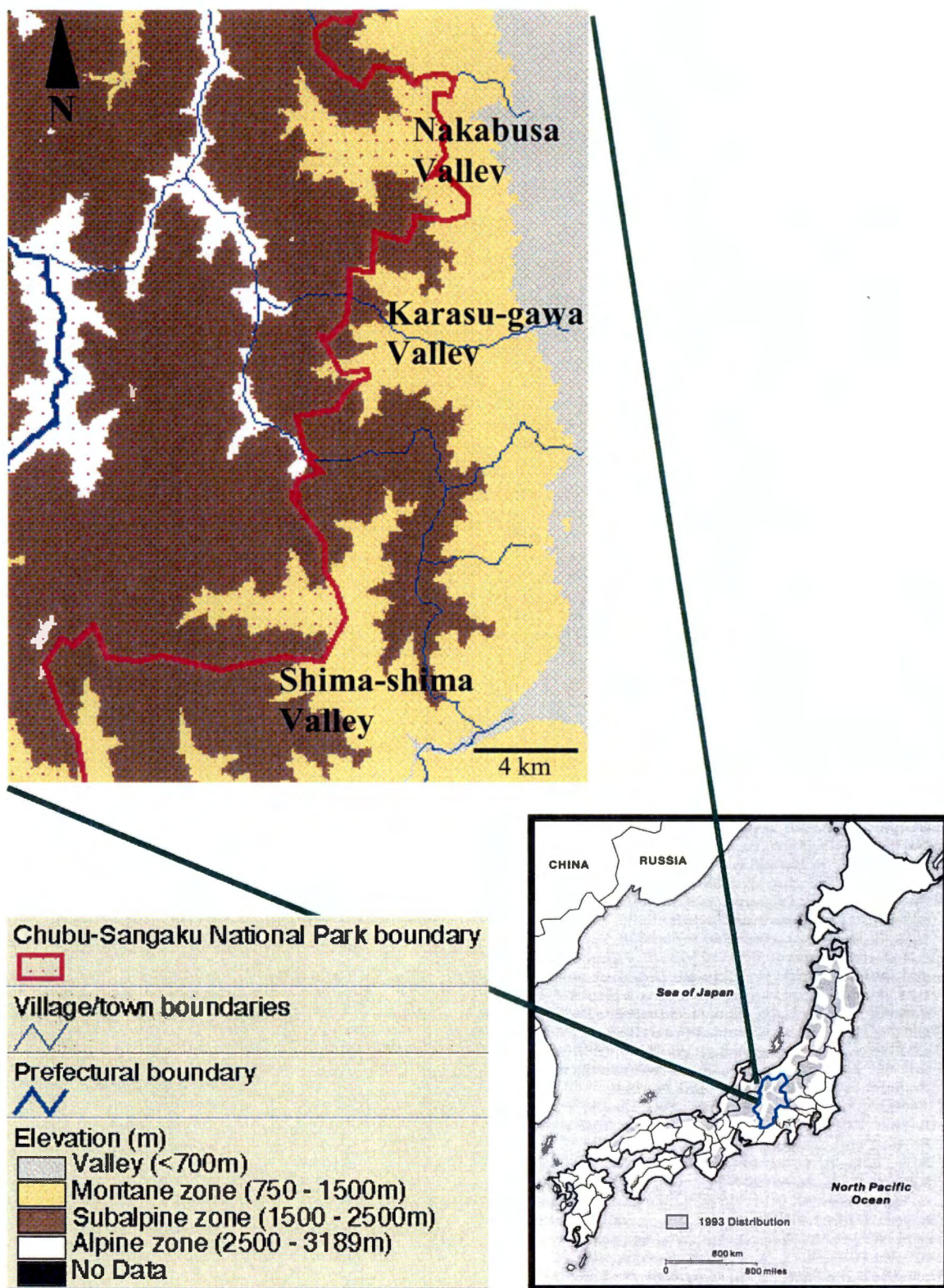


Fig. 2-1. Study area for Asiatic black bear in Nagano Prefecture, Japan, 1997-99.

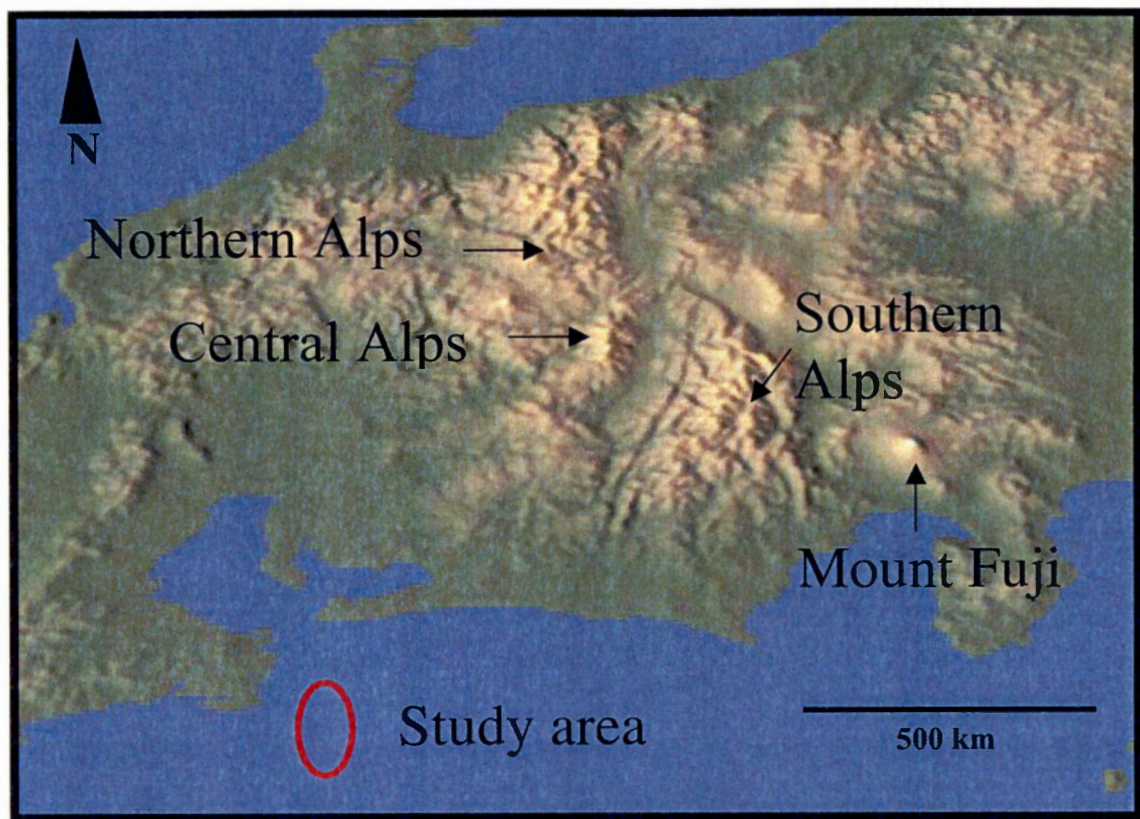


Fig. 2-2. Study area for Asiatic black bears and the region around Nagano Prefecture, Japan, 1997–99.

CLIMATE AND VEGETATION

Climate information was collected from a village located east of the Karasu-gawa drainage. During the research season (from June to November), the average monthly temperatures ranged from 7°C to 24°C. Based on monthly averages from 1979–1990, total yearly precipitation was 967 mm. Snowfall, which mainly falls from December to March, was 910 mm (approximate rain equivalency: 76 mm).

Three vegetation zones existed within the study area (Numata 1974, Huygens 1998). The montane zone was found from the lowest elevations in the valleys up to 1,500 m. *Fagus crenata* and *Quercus crispula* often dominated the overstory with bamboo grass (*Sasa* spp.) as the main understory component. Bamboo grass was particularly dominant in disturbed areas, where it often prevents forest regeneration (Taylor et al. 1991, Taylor and Zisheng 1993). Logging, subsequent plantations, and other developments have altered natural vegetation in this zone. The sub-alpine zone ranged from 1,500 m to 2,500 m. *Abies veitchii* and *A. mariesii* dominated the sub-alpine canopy. The shrub layer was often poorly developed, although *Viburnum furcatum* and several species of *Sorbus* were common. The alpine zone was above 2,500 m. *Pinus pumila*, the Japanese stone pine, grew in dense thickets and usually was the main component in this zone. Alpine heaths, grasslands, and deserts occurred in areas with environmental disturbances or harsh conditions (Huygens 1998).

LAND USE

Approximately half of the study area was within Chûbu-Sangaku National Park (Fig. 2-2), located above 1,500 m. However, most of the data for this project were

collected in the remaining portion because of the extreme topography above 1,500 m and concentration of bear activity in the montane zone.

Human density was high in the valleys to the east and south of the study area. Within the study area, the most common human activities were associated with logging, hydroelectric industry sites, tourism, golf courses, homes, and roads. The pace of development in the mountains is increasing (Roy 1998), with most development occurring in the montane zone. More than 1,000 hikers a day used the most popular trails during the hiking season from July to early fall (Mountain Safety Volunteer, Mitsumata Trailhead Registration Office, personal communication). Little development was found in the region between alpine lodges and the lower montane zone.

CHAPTER 3

METHODS

CAPTURE AND HANDLING

In cooperation with the Shinshû Asiatic Black Bear Research Group, I trapped bears from June to November 1998 and June to October 1999. This group was responsible for bears captured in the study area before June 1998. I assisted with trapping from June to November 1997. In 1998 and 1999, I continued trapping 5 sites that were previously trapped. Selection of these sites was based on previous trapping success and permission from landowners. Trap site selection based on randomized locations or a systematic grid was not practical due to limited access, so I usually placed trap sites on ridges (Fig. 3-1).

All 5 initial sites were located around elevations of 1,000 m. Trap T05 was in Nakabusa Valley, while Traps T01, T02, T03, and T04 were in Karasu-gawa Valley. In addition to these 5 traps, Trap T13 was placed at the garbage dump of an alpine lodge and Trap T09 was at an apiary where bear damage had occurred. I added 3 traps around 1,500 m in 1999 to increase the elevation range of trapsites. Bears were captured in adjacent areas, but data collected in these areas became the responsibility of another researcher.

I used culvert traps designed to minimize trap injuries. Traps were baited with honey and honeycomb through 1998. I also used fish oil (J. Clark, U.S. Geological Survey, personal communication) and canned sardines as scent attractants in 1999. I

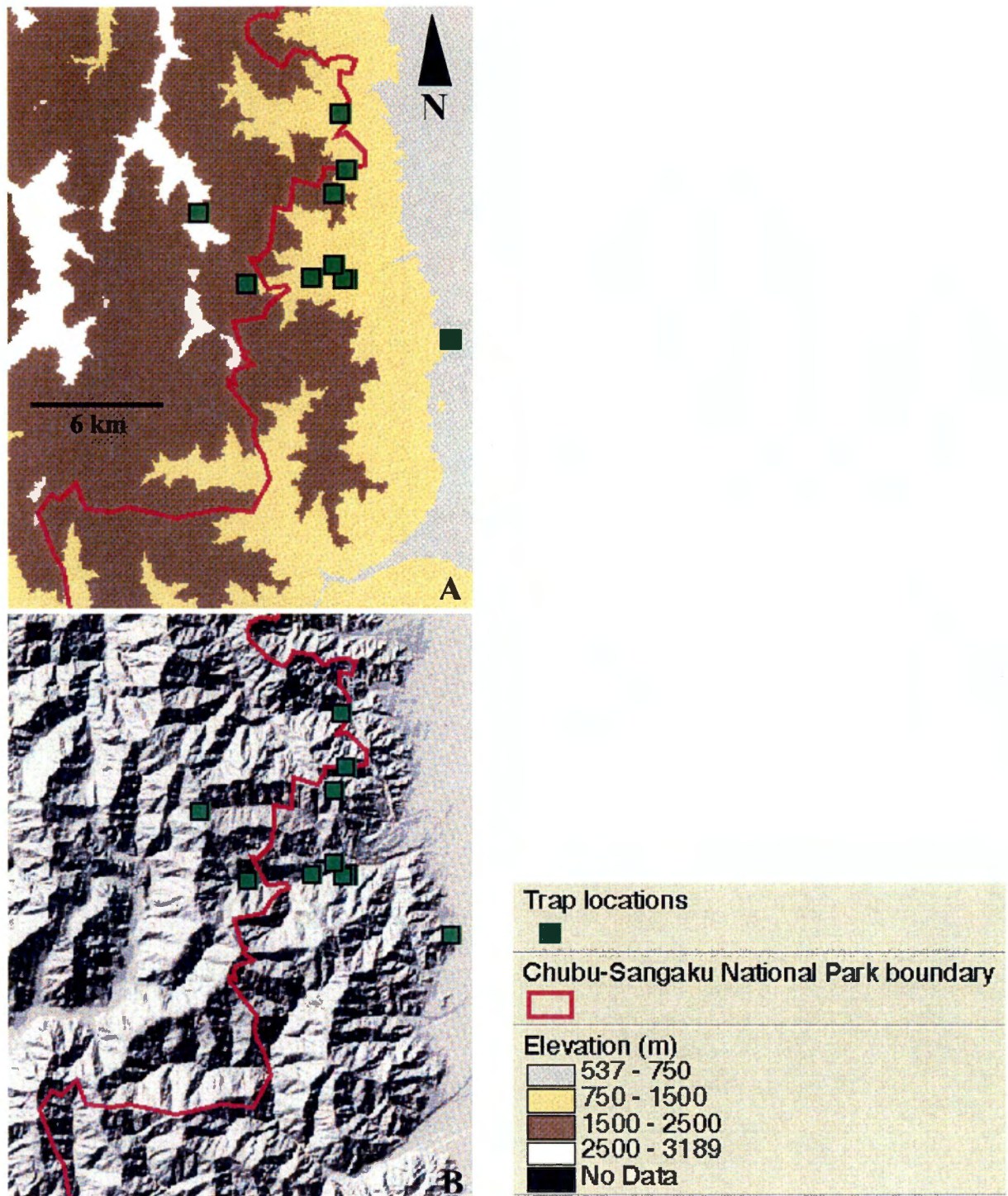


Fig. 3-1. Elevation (A), terrain (B), and trap locations to capture Asiatic black bears, Nagano Prefecture, Japan, 1997-99.

checked traps each day with a remote receiver and a transmitter that would stop signaling when the trap door closed. The original transmitter was replaced with a new design in summer 1998. I visually checked traps every 2-4 weeks, then weekly from late summer 1998, and biweekly during the entire 1999 field season. I refreshed bait and attractants as needed.

All trapped bears were handled within 24 hours after a capture event was confirmed. I used a blowgun and 3 cc, hand-made darts (Carriles 1993) to administer tranquilizers. Bears were immobilized with an intramuscular injection of ketamine hydrochloride (Park Davis, Tokyo, Japan) at a dosage of 15 mg/kg and xylazine hydrochloride (Bayer, Tokyo, Japan) at a dosage of 1 mg/kg. Atropine was administered as a muscle relaxant at a dosage of 0.025 mg/kg through 1997. Its use was discontinued because it seemed ineffective. If a bear was not adequately sedated after 10 minutes, I administered an amount of additional drug based on estimated weight and behavior of the bear.

After immobilization, I applied a wetting agent (Phizer, New York, New York, USA) to the eyes of bears to prevent desiccation. Bears were blindfolded to reduce visual stimuli and risk of injury. I recorded the weight, standard body measurements, general condition, and unusual characteristics or observations. I extracted an upper premolar for age analysis (Willey 1974) by a Japanese laboratory (Wildlife Management Offices, Kawasaki, Kanagawa, Japan) until 1997 and by an American laboratory (Matson's Laboratory, Milltown, Montana, USA) for 1998 and 1999. Hair, blood, and tissue samples were collected for DNA analysis by an independent project (Shinshû University,

Matsumoto, Nagano, Japan). I created a 4-mm opening in the ear to insert a plastic ear tag with a unique identification number. Beginning in 1998, I tattooed the inside of the upper lip with letters corresponding to the ear tag number (e.g., 13 = 1st and 3rd letter = AC).

Captured bears of sufficient size (>20 kg) were fitted with radio collars (Advanced Telemetry Systems, Minnesota, USA and Lotek, Ontario, Canada). Two bears (F06 and M13) were given collars with activity switches, which respond to bear movement over designated time periods. Because 1 female (F06) was exceptionally small (22 kg), I attached a collar of soft nylon belting. On bears expected to grow, I attached additional leather bands and layers of electrical tape inside the collar loop that were intended to degrade and allow collar expansion. After 1998, I included 1 to 3 layers of spacers made of highly degradable leather (usually soaked in vegetable oil) as an integral part of the collar loop.

Bears recovered from sedation in a closed trap and were released after they regained control of their legs ($\approx$ 1 hour after they first lifted their head). From a position >3 m high in a tree, I opened the door with a rope. I made 1 exception and allowed a 29-kg female (second capture of F06) to recover with an open door and leave when able. I observed her from a tree 10 m from the trap.

TELEMETRY

I used a whip antenna (Comet Company, Urawa City, Saitama Prefecture, Japan) mounted on a vehicle roof to scan for collar signals. Researchers located bears using a

CB receiver (FT-290mkII, Yaesu, Tokyo, Japan/California, USA) and 4- or 6-element, hand-held yagi antennas (YA-23L, Araki, Tokyo, Japan, until 1997, then F144-3FB-148 from AF Antronics, Inc., Urbana, Illinois, USA). I estimated directional azimuths using the loudest signal method (Springer 1979, Mech 1983), which was aided by a meter for signal strength on the receiver. Locations usually were recorded on bears every 3 to 5 days between 0800 and 1600 hours.

I could not use readings from Global Positioning System receivers because of extreme and continuous shifts of the coordinates up to hundreds of meters. Therefore, I marked telemetry stations directly onto a copy of a 1:25,000 topographic map (Kokutouchi Ri-in/Japan Map Center, Tokyo, Japan). Date, weather, and temperature were recorded once during each triangulation. Additionally, I recorded station, time, azimuth, and signal strength at each station.

Because declination in the study area ranged from 6°50' to 7°10', I chose to adjust azimuths to 7° W. I inscribed station locations on an original map and gave each an identification number. I created grids that measured decimal minutes based on the latitude-longitude matrix. I converted decimal minutes to Universal Transverse Mercator (UTM) values using Microsoft Excel and Arc/Info (Environmental Systems Research Institute, Redlands, California, USA).

TRIANGULATION ERROR ANALYSIS

I used the azimuths from at least 2 station points (Nams and Boutin 1991) to determine each bear location. I reduced location error by (1) setting the maximum time

between azimuths to 30 minutes and (2) limiting the angle between the azimuths from 45° to 135°. I eliminated locations that were within these limitations if they identified a capture or den site. I also eliminated any location estimates that were deemed unreliable in the field or were based on transmissions from an undetected dropped collar (e.g., 17 locations from M07 were eliminated when his collar was found in 1996).

Exactly 1,479 azimuth pairs or visual locations from 21 different bears were considered valid for entry into the triangulation program, Telem88 (Coleman and Jones 1986). Telem88 performed triangulation and eliminated locations according to time and angle limitations. Additionally, I only used data from bears with 14 or more locations after triangulation processing. Those selection criteria resulted in 507 location estimates of 13 different bears.

HOME RANGE AND HABITAT USE

Movement

I used the Animal Movement extension (Hooge et al. 1999) in ArcViewGIS® (Environmental Systems Research Institute, Redlands, California, USA) to determine circuitry for the entire period that the bears were monitored. Circuitry is defined as the net movement divided by total movement, and provides an estimate of linear movement. A value around 0 indicates that an animal returned close to its original location. Values close to 1 indicate that an animal moved on a straight path from its starting point.

Home Range

For this study, a home range is defined as the area in which an animal moved for its normal activities (Burt 1943). I used the animal movement extension (Hooge et al. 1999) in ArcViewGIS® to determine home ranges with minimum convex polygon (MCP) and fixed kernel methods (Worton 1989). The minimum convex polygon method is non-statistical and connects the outermost locations of an animal to create a polygon with the smallest possible area. The kernel method creates a probability density estimate of a distribution based on the sample of locations. The fixed versus the adaptive kernel method was used because it is available in ArcViewGIS® and has lower bias (Seaman et al. 1998). I created 50%, 75%, and 95% contours. I used different datasets depending on the method of home range analysis. MCP home ranges were calculated for all 13 bears. However, because kernel home range estimation requires relatively large sample sizes (Seaman et al. 1999), I used only bears with >40 locations ($n = 7$).

When the 95% home range contour is calculated for the fixed kernel methods, the home range size is larger compared with other methods, such as grid-cell and harmonic mean. However, when contours of lower percentages are calculated, the resulting polygon often is considered to illustrate core areas of habitat use.

Habitat Use

Vegetation data were obtained from the Nagano Nature Conservation Research Institute (Nagano City, Nagano Prefecture, Japan). The vegetation data I used in my analysis were collected in 1985. Although vegetative conditions may have changed

during the last 15 years, few bear locations were in forest types that may have drastically changed (i.e., cut forest). Moreover, forest development is relatively slow (Nyland 1996). Therefore, the 1985 data probably were reliable for the habitat analyses.

I translated the vegetation category names and classified the vegetation within the study area into 12 categories (Table 3-1). There are two forest classifications that were managed for timber. Planted forests were regenerated through planting. Cut forests regenerated poorly, usually because of colonization by bamboo grass. For each bear location, I determined the corresponding vegetation type (Fig. 3-2 and 3-3) with ArcViewGIS[®]. Elevation data were obtained from the Japan Map Center (Tokyo, Japan); other topographic characteristics were generated from those data. I classified each location by elevation, slope, aspect, terrain shape index (McNab 1990), and distance from the nearest road using the SAMPLE command under GRID in Arc/Info[®].

I used the animal movement extension (Hooge et al. 1999) in ArcViewGIS[®] to generate 2 sets of random locations. One set was generated within the MCP for the entire population, whereas the second set was created within the MCP of each bear. The number of random locations was equal to the number of actual locations that was used to generate each MCP. I matched ID, sex, age, month, season, and year from actual locations with the generated ones. Assignment of these associated data was unbiased because the order of random locations was independent of the actual locations. I obtained vegetation and topographic information for the random locations, as previously described.

Table 3-1. Vegetation types and codes for the classification and regression tree analysis and Mahalanobis models to determine habitat use of Asiatic black bear in Nagano Prefecture, Japan, 1997–99.

CART model vegetation types		Mahalanobis model vegetation types	
Code	Name	Code	Name
1	Alpine	1	Other
2	Bamboo grass	1	Other
3	Non-forest	1	Other
4	Oak-dominated forest	3	Deciduous forest
5	Deciduous forest	3	Deciduous forest
6	Mixed broadleaf-conifer forest	2	Mixed broadleaf-conifer forest
7	Agriculture	1	Other
8	Logged forest	4	Cut forest
9	Planted forest	5	Planted forest
10	Developed	1	Other
11	Riparian and water bodies	1	Other
12	Barren/unknown	1	Other

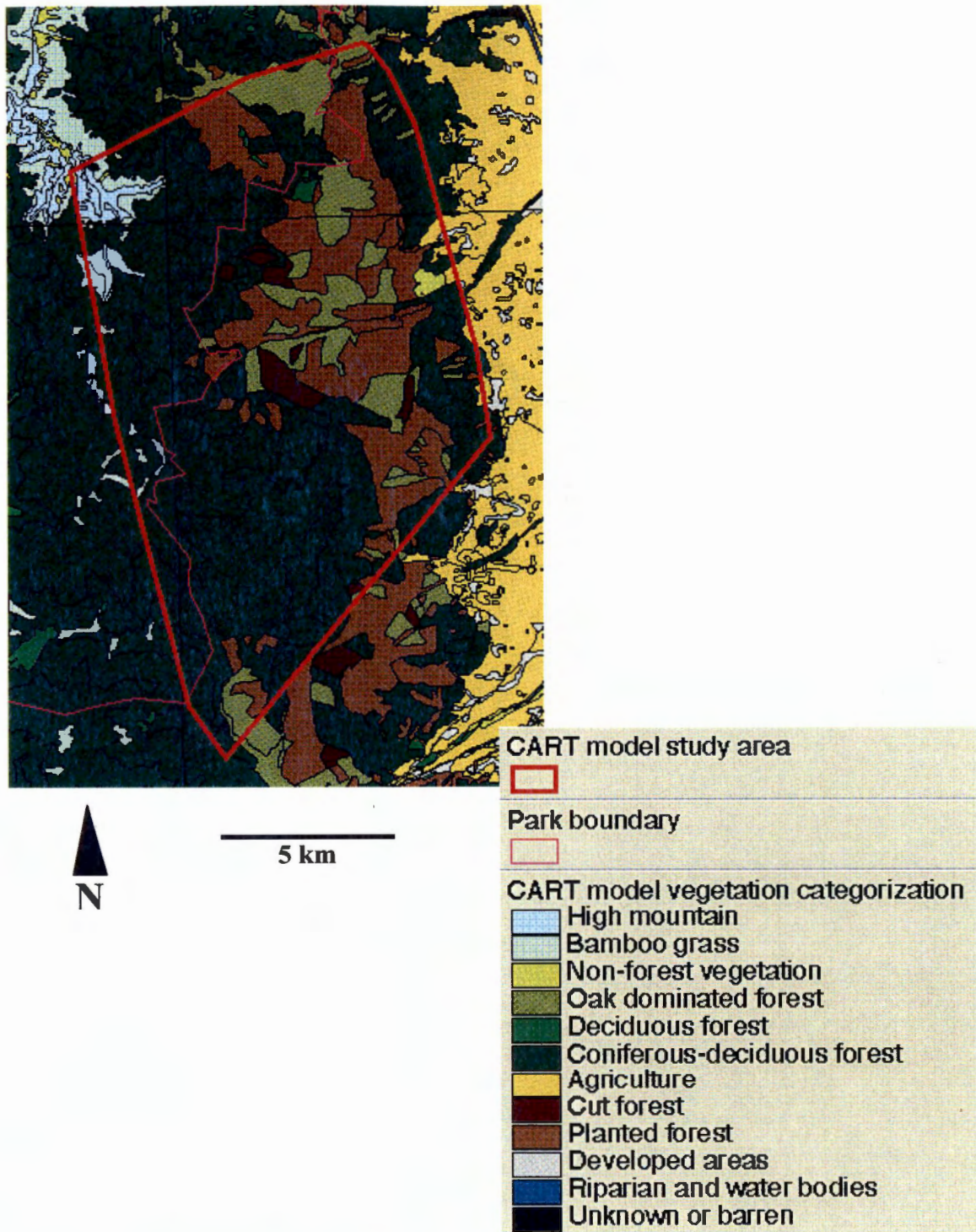
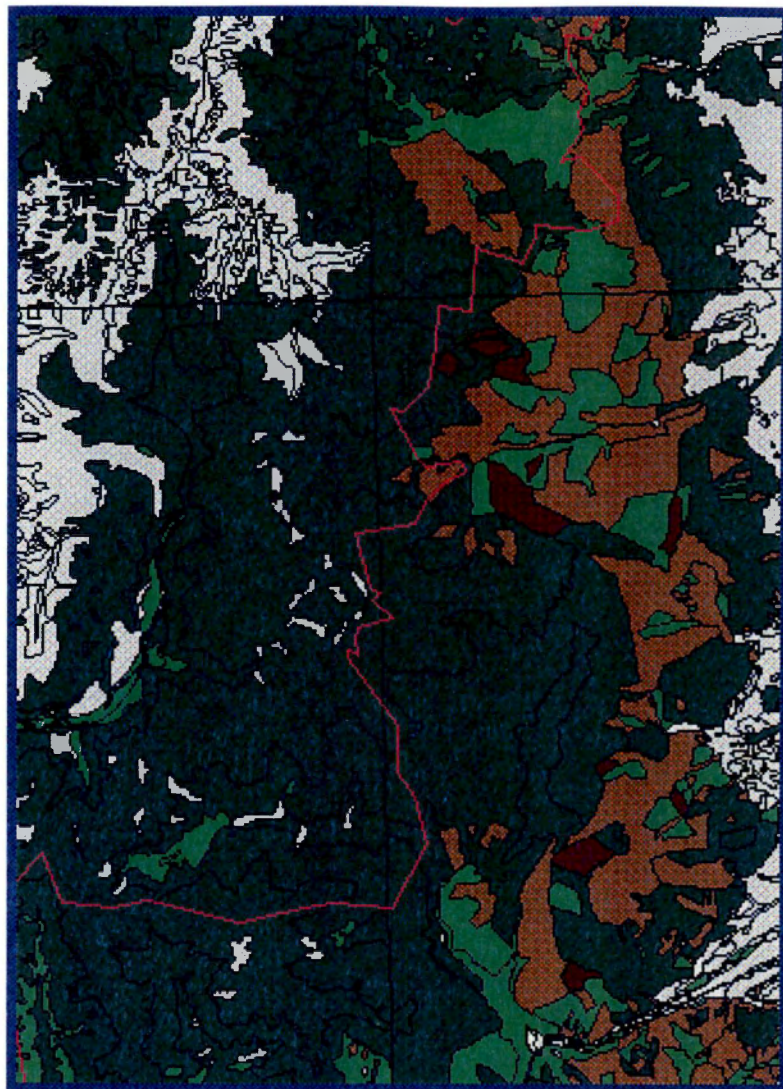


Fig. 3-2. Classification and regression tree analysis (CART) model study area and vegetation types to determine habitat use of Asiatic black bears, Nagano Prefecture, Japan, 1997–99.



4 km

Mahalanobis model study area



Park boundary



Mahalanobis model vegetation categorization



Other



Coniferous-Deciduous Forest



Deciduous forest



Cut forest



Planted forest

Fig. 3-3. Mahalanobis model study area and vegetation types to determine habitat use of Asiatic black bears, Nagano Prefecture, Japan, 1997–99.

I used SSPS Answer Tree[®] software to perform a classification tree analysis. Classification trees can be useful to summarize large, multivariate datasets (Clark and Pregibon 1991) by identifying important variables (Venables and Ripley 1994, Clark et al. 1999) and structure of a dataset (Clark and Pregibon 1991, Dobbertin and Biging 1998). I created a binary, dependent variable based on locations being random or actual bear locations. The following independent variables were included: vegetation type; individual bear characteristics, including ID, age, and sex; location timing, including year, month, and season; and terrain characteristics, including elevation, aspect, and slope. I initially ran 53 models that indicated habitat use patterns were not different among individuals. Therefore, subsequent analyses used models based on the random locations that were generated within the composite MCP home range of all bears (Fig. 3-2).

The basis of the classification tree is formed by variables that are good predictors of data patterns and lead to the most homogenous division form. However, exclusion from the model does not discount the importance of a variable (Clark and Pregibon 1991). Earlier splits may be of greater importance if later nodes carry few data points. Also, relative importance of nodes is indicated by percentage gain, which indicates the homogeneity of the split. Model differentiation focuses on the branch of nodes having not only the greater number of bear locations, but also a greater difference between the proportion of bear and random locations. Nodes with these characteristics indicate how habitat parameters associated with bear locations deviates from random locations. I evaluated the relative fit of the model to the data by calculating the risk rate of

misclassification (Clark and Pregibon 1991, SPSS 1999). The models with the lowest percentage of misclassification, reported in the output of the program, were candidates for being representative models of the data.

I performed a second habitat analysis by developing a multivariate model of habitat quality based on Mahalanobis distance (Rao 1952, Morrison 1976, Clark et al. 1993). Mahalanobis distance is a measure of dissimilarity (Clark et al. 1993) between the sample units, which are grid cells in this analysis. Mahalanobis distance is a statistic that is calculated from the following formula:

$$D^2 = (\underline{x} - \underline{\hat{u}})' \Sigma^{-1} (\underline{x} - \underline{\hat{u}}),$$

where the vector $\underline{x}$ represents the values for each variable for a particular cell. These characteristics are compared to the vector of means ($\underline{\hat{u}}$), which was calculated from the 507 sampled bear locations and represents the “ideal” habitat conditions. The inverse of the variance-covariance matrix from the sampling points is Σ^{-1} . These calculations result in a value for D^2 , for each 50-x-50 m cell in the study area. A smaller D^2 indicates higher quality habitat for bears (Clark et al. 1993). Variables are standardized to eliminate problems associated with different measurement scales. Different combinations of the variable values can achieve similar values of D^2 (Clark et al. 1993). The relative importance of variables in the multivariate model is indicated by standard deviation, which is the diagonal of the variance-covariance matrix (Clark et al. 1993).

Habitat data consisted of the following variables: distance to nearest road, terrain shape index, aspect, elevation, slope, and vegetation type. These variables were chosen

because of their potential association with bear habitat quality (Kasworm and Manley 1990, Beringer et al. 1990, Garshelis and Pelton 1981, Clark et al. 1993, van Manen and Pelton 1996, Powell and Mitchell 1998). Aspect was converted to a numerical variable on a 0.0–2.0 scale with Beers’ transformation (Beers et al. 1966):

$$\text{Beers' aspect value} = 1 + \cosine(45 - \text{aspect}).$$

In this analysis, I categorized the vegetation data into 5 types (Table 3-1) based on relative concentration of bear locations. Because vegetation type is a categorical variable, I developed 4 design variables to represent the 5 vegetation types. I delineated a larger area for model application (432 km²) (Fig. 3-3) to extrapolate the model to areas outside of the CART model study area. I pooled locations across years and individuals because the 53 initial CART models indicated that habitat use patterns did not differ among individuals.

CHAPTER 4

RESULTS

CAPTURE AND HANDLING

The Shinshû Asiatic Black Bear Research Group and I captured 28 bears 33 times from 1996–99 (Table 4-1). Trap nights were not recorded prior to 1999. For the 9 traps used in 1999, trapping efficiency was 47 trapnights per capture ($n = 10$ captures). One cub was captured with an adult female in the same capture event. Three bears were captured, but not handled. Of those not handled, one bear died in trap T02 because of a trap transmitter malfunction. Another bear was accidentally released from trap T03. One yearling was intentionally released from trap T04 to prevent continued conflict at the trapsite with an adult and a second yearling.

The sex ratio of captured bears (6 F, 19 M) (Table 4-2) was different from 1:1 ($X^2 = 6.76$, $df = 1$, $P < 0.01$). Two bears were caught in association with nuisance behavior; 1 at a garbage dump of a lodge (M19) and 1 at an apiary (M38). The age of 23 handled bears ranged from approximately 8 months to 18 years ($\bar{x} = 6.5$, $SD = 4.7$, $n = 23$). The ages of 2 bears (M12 and M13) were not obtained because teeth were damaged during extraction.

Two bears (M30 and the second recapture of F06) were exceptionally aggressive when released. Yelling averted F06 before she came in contact with anyone. M30 was repelled by pepper spray before he could seriously harm a researcher.

Table 4-1. Asiatic black bear captures in Nagano Prefecture, Japan, 1996–99^a.

Trap ID	Trap Location	Number of capture events				
		1996	1997	1998	1999	Total
T01	Omizu slope	1	2	3	1	7
T02	Omizu ridge	2	1	0	2	5
T03	Powerline	1	2	1	2	6
T04	Dam	1	2	1	0	4
T05	Nakabusa	0	2	0	3	5
T06	Knob	---	---	---	1	1
T07	High Ichinosawa	---	---	---	1	1
T08	Mitsumata	---	---	---	0	0
T09	Yaguchi apiary	---	---	1	0	1
T13	Jonen lodge	0	1	---	---	1
Total		5	10	6	10	31

^a Trapping for research purposes only began in adjacent areas in 1995 and there were no recaptures in the study area until 1997. Bears that were recaptured ($n = 5$) and captured but not handled ($n = 3$) are included. Bears that were not handled are included in this table only. One cub (M31) captured in trap T05 with an adult (F32) in 1997 was not counted as a separate capture event.

Table 4-2. Characteristics of Asiatic black bears captured in Nagano Prefecture, Japan, 1996–99 ^a.

Bear ID	Tattoo	Sex	Used in analysis	Release Date	Damage Capture	Trap Site	Weight (kg)	Age (years)	Name	Notes
F06	DF	F	Y	06-Sep-96	N	T04,T04, T03	22	3.5	Naoko	Recapture 3 Aug 97 (29 kg); 8 Jul 99 (41 kg); new tags = F46
M07	None	M	N	06-Sep-96	N	T02,T03	31	3.5	Shuhei	Recapture 26 Aug 97 (37 kg)
M08	None	M	Y	06-Sep-96	N	T01	46	4.5	Masaaki	
F10	None	F	N	15-Sep-96	N	T02	39	18.5	Aki	Cubs present - possibly hers; collar possibly failed
M11	None	M	Y	22-Oct-96	N	T03	69	5.5	Rokube	
M12	None	M	N	19-Jul-97	N	T01	84	---	Nobita	Age unknown - bad extraction; collar dropped
M13	None	M	Y	20-Jul-97	N	T03	65	---	Yasuo	Age unknown - bad extraction
M19	None	M	Y	12-Aug-97	Y	T13	95	8.5	Kentaro	Lodge
M28	None	M	Y	04-Oct-97	N	T02,T01	36	3.5	Takiyo	Collar dropped twice; recapture: 25 June 98 (44 kg)
M30	None	M	N	07-Oct-97	N	T01	103	14.5	Yosuke	Lost soon after capture
M29	None	M	Y	18-Oct-97	N	T05	103	8.5	Baloo	
F32	None	F	Y	26-Oct-97	N	T05	66	10.5	Keiko	Captured with cub
M31	None	M	N	26-Oct-97	N	T05	19	0.5	Ayako	Captured with adult; released without a collar
M35	CE	M	N	20-Jun-98	N	T01,T04	21	1.5	Ryohei	Released without a collar; recapture 2 July 98
F37	CG	F	Y	01-Jul-98	N	T01	28	2.5	Hiromi	Collar failed or lost
M38	CH	M	Y	11-Jul-98	Y	T09	73	13.5	Jiro2	Collar dropped Sept.-Oct. 98; apiary
F43	DC	F	Y	30-Jun-99	N	T03	42	7.5	Emiko	
M44	DD	M	N	04-Jul-99	N	T01	28	1.5	Indy	Released without a collar
M45	DE	M	N	05-Jul-99	N	T05	45	3.5	Gon	Lost within 1 week of capture
M47	DG	M	N	10-Jul-99	N	T02	88	11.5	Hiroshi	
M49	DI	M	Y	03-Aug-99	N	T06	51	3.5	Pierre	
M51	EA	M	N	06-Aug-99	N	T05	60	7.5	Tetsuya	Lost within 2 weeks of capture
F53	EC	F	Y	18-Aug-99	N	T07	49	10.5	Akane	
M54	ED	M	N	28-Aug-99	N	T05	21	1.5	Ayao	Released without a collar
M55	EE	M	N	02-Sep-99	N	T02	34	2.5	Kazuo	Released without a collar

^a Internal lines divide bears by year of capture/release; Y = yes, N = no.

TELEMETRY

Seven bears were released without collars, of which 5 were subadult males (Table 4-2) and 2 were not handled. Four collars dropped while the collar was still functioning. Four additional collars malfunctioned, dropped, or were fitted on a bear in areas that went out of reception range (from initial loss of contact until the end of the project).

Triangulation Error Analysis

Initially, 1,479 pairs of azimuths from 21 bears were considered reliable for triangulation analysis, resulting in 507 locations on 13 bears (Fig. 4-1). I only used the telemetry data on those 13 bears from 15 May 1997 to 4 November 1999 (Fig. 4-2).

Movement

Circuitry values ranged from 0.006 to 0.318 ($\bar{x} = 0.057$, $SD = 0.080$, $n = 13$).

Circuitry for M08 was high (0.318). Excluding the extreme value for M08, mean circuitry was 0.036 ($SD = 0.028$, $n = 12$).

Home Range

The average MCP home range for the 13 bears was 18.7 km² ($SD = 13.4$).

Female home ranges were smaller ($\bar{x} = 10.0$ km², $n = 5$) (Fig. 4-3) than those of males ($\bar{x} = 24.2$ km², $n = 8$) (Fig. 4-4), but they were not statistically different ($t = 1.99$, $df = 11$, $P = 0.05$). Home ranges also differed when bears were grouped according to the valley

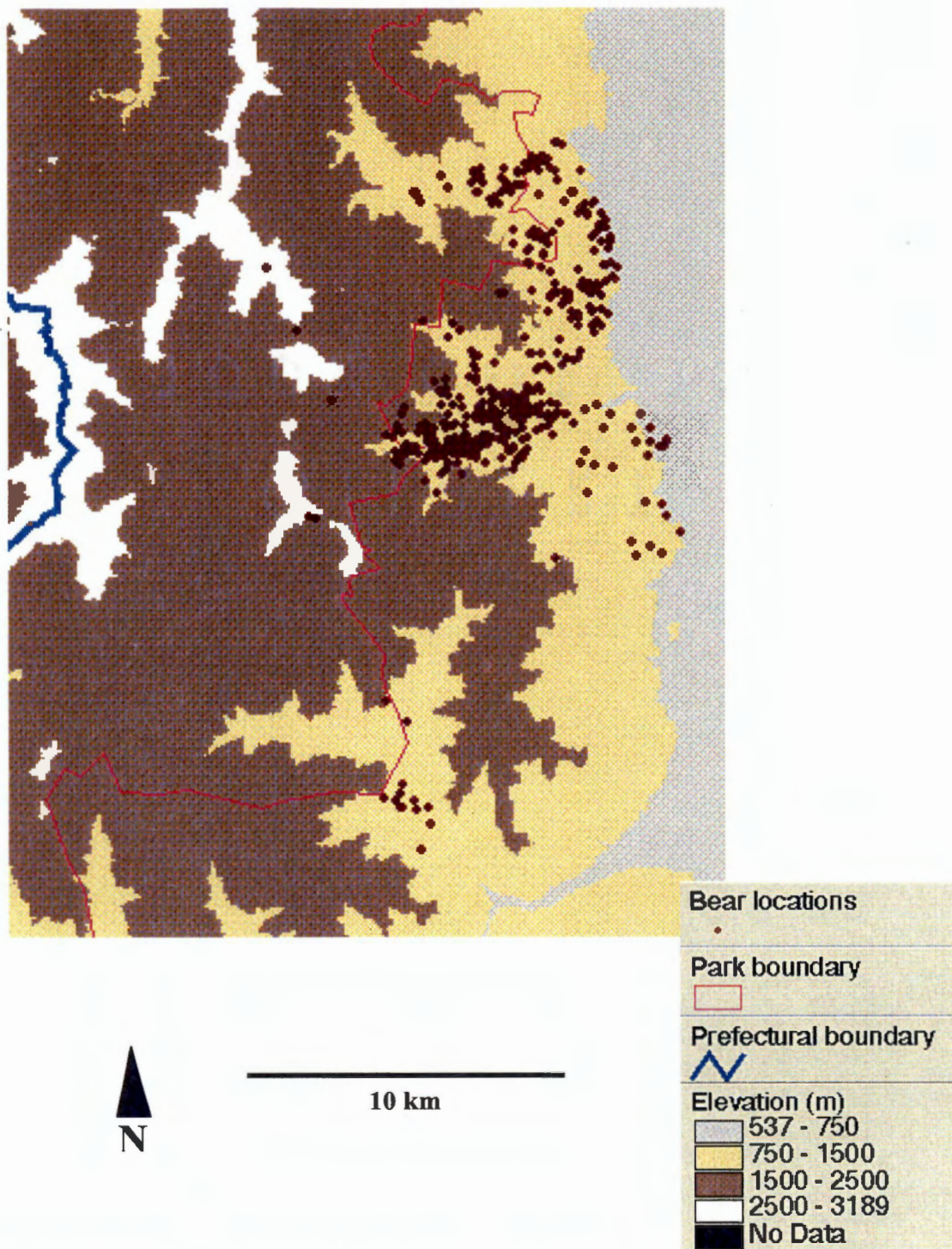


Fig. 4-1. Locations of Asiatic black bears in relation to a national park boundary and elevation, Nagano Prefecture, Japan, 1997–99.

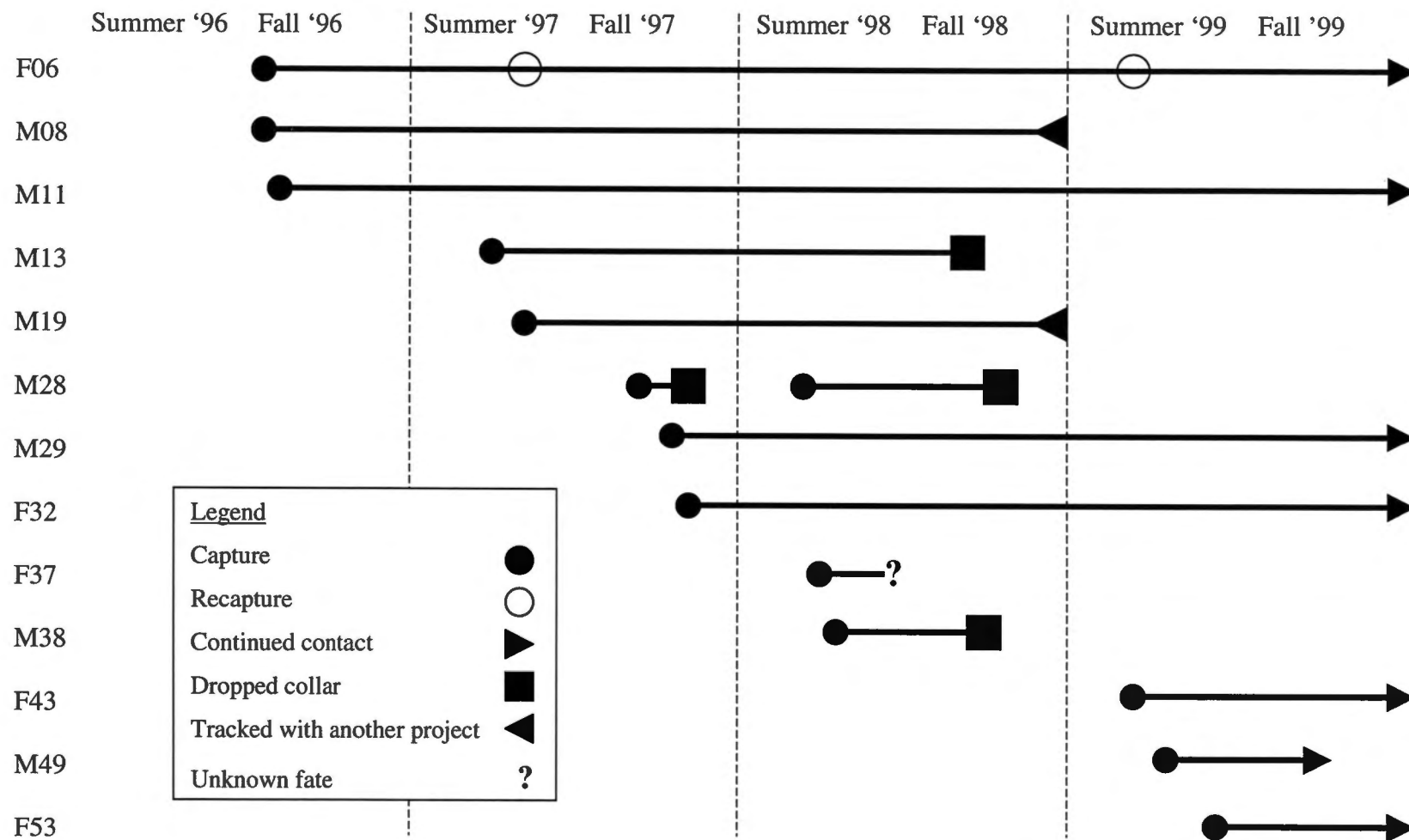


Figure 4-2. Tracking history of Asiatic black bears in Nagano Prefecture, Japan, 1996–99.

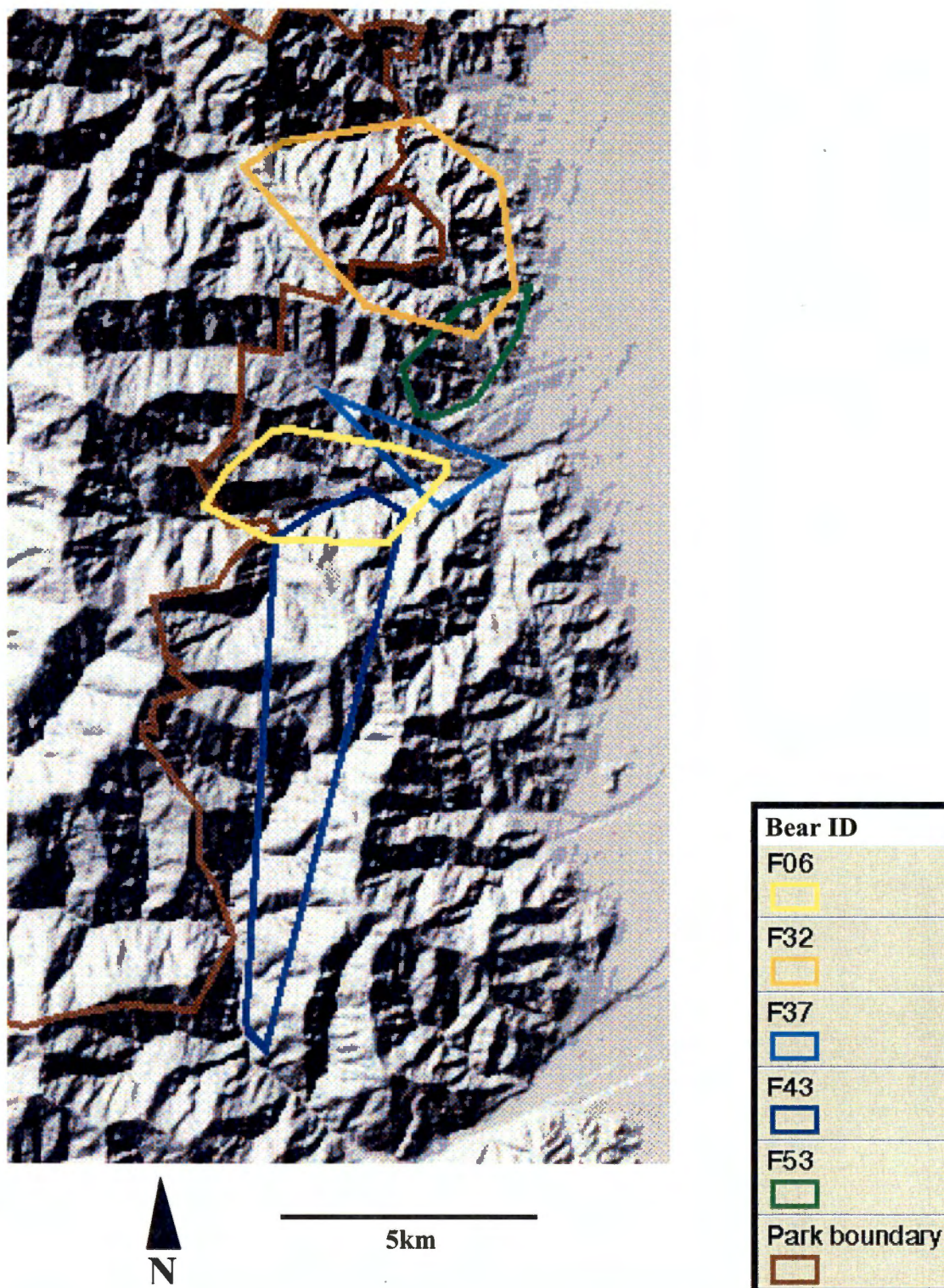


Fig. 4-3. Minimum convex polygon home ranges of female Asiatic black bears, Nagano Prefecture, Japan, 1997-99.

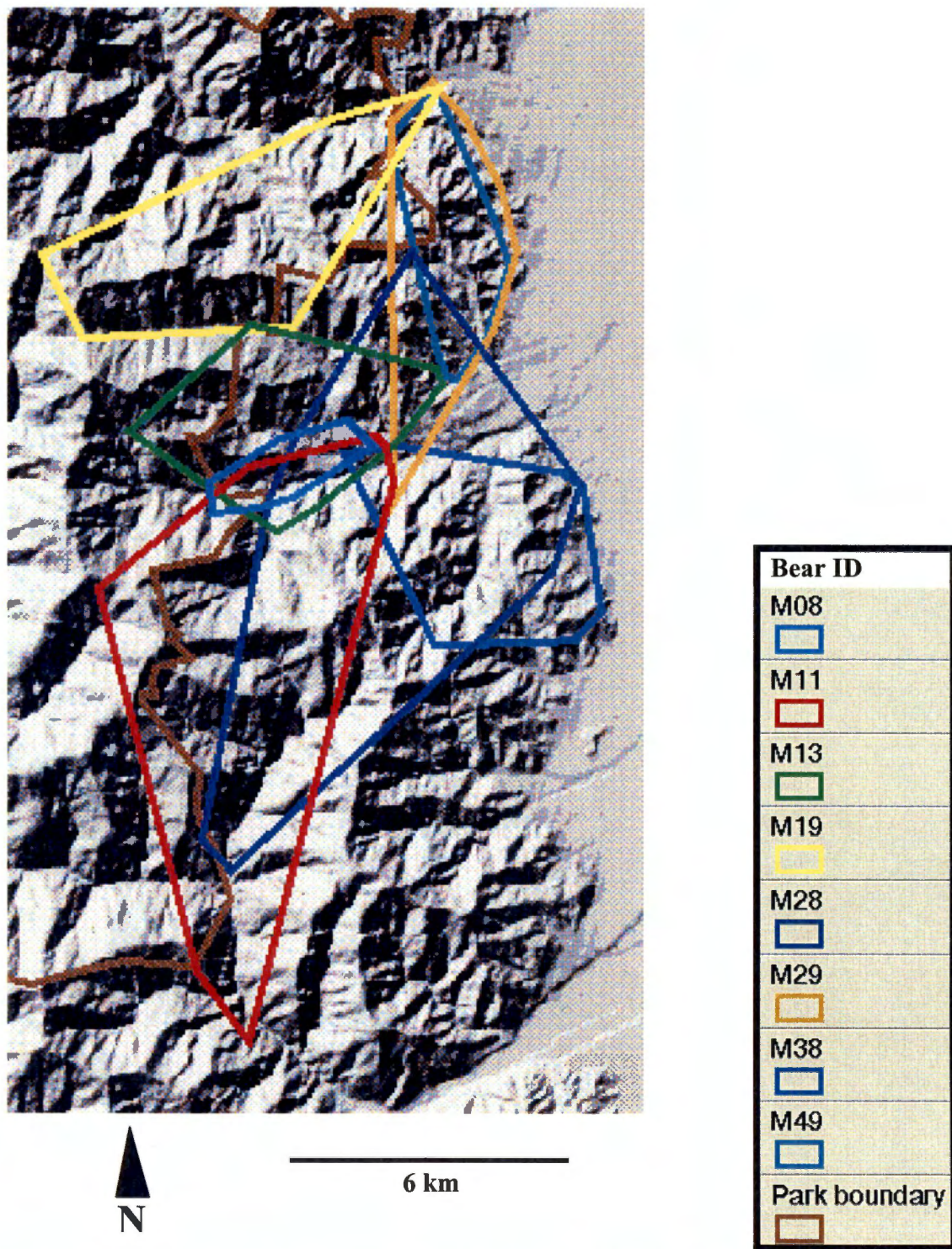


Fig. 4-4. Minimum convex polygon home ranges of male Asiatic black bears, Nagano Prefecture, Japan, 1997-99.

where they were located the majority of the time. The average home range for bears in Nakabusa Valley and Karasu-gawa Valley was 15.8 km² ($n = 4$) and 20.0 km² ($n = 9$), respectively. However, these averages also were not statistically different ($t = 0.11$, $df = 11$, $P = 0.05$).

Home ranges of 7 bears were analyzed with the kernel method. The average home range sizes for the 95%, 75%, and 50% contours were 24.2 km² (SD = 15.1), 20.4 km² (SD = 7.4), and 8.4 km² (SD = 3.2), respectively.

Habitat Use

From the 32 CART models I developed with the pooled data, I selected 1 model from the 3 with the lowest risk of misclassification (<25%). This model included the variables: sex, age, year, season, elevation, aspect, slope, and vegetation type. The first and third splits of the dominant branch (a branch with the largest divergence of actual locations compared with random locations) were at elevations $\leq 1,459$ m and $\leq 1,224$ m, respectively (Fig. 4-5). The node with the most gain (76%) was based on vegetation type at the second split of the dominant branch (Fig. 4-5). This split indicated that bears use oak, cut, and planted forest types more than random. That is, of the locations at or below 1,459 m, 73% were actual locations in those 3 forest types. The 50% kernel contours of many bears showed distinctive overlap with patches of oak-dominated forest, illustrated by the 5 bears in Fig. 4-6, lending additional support the importance of these types of forest.

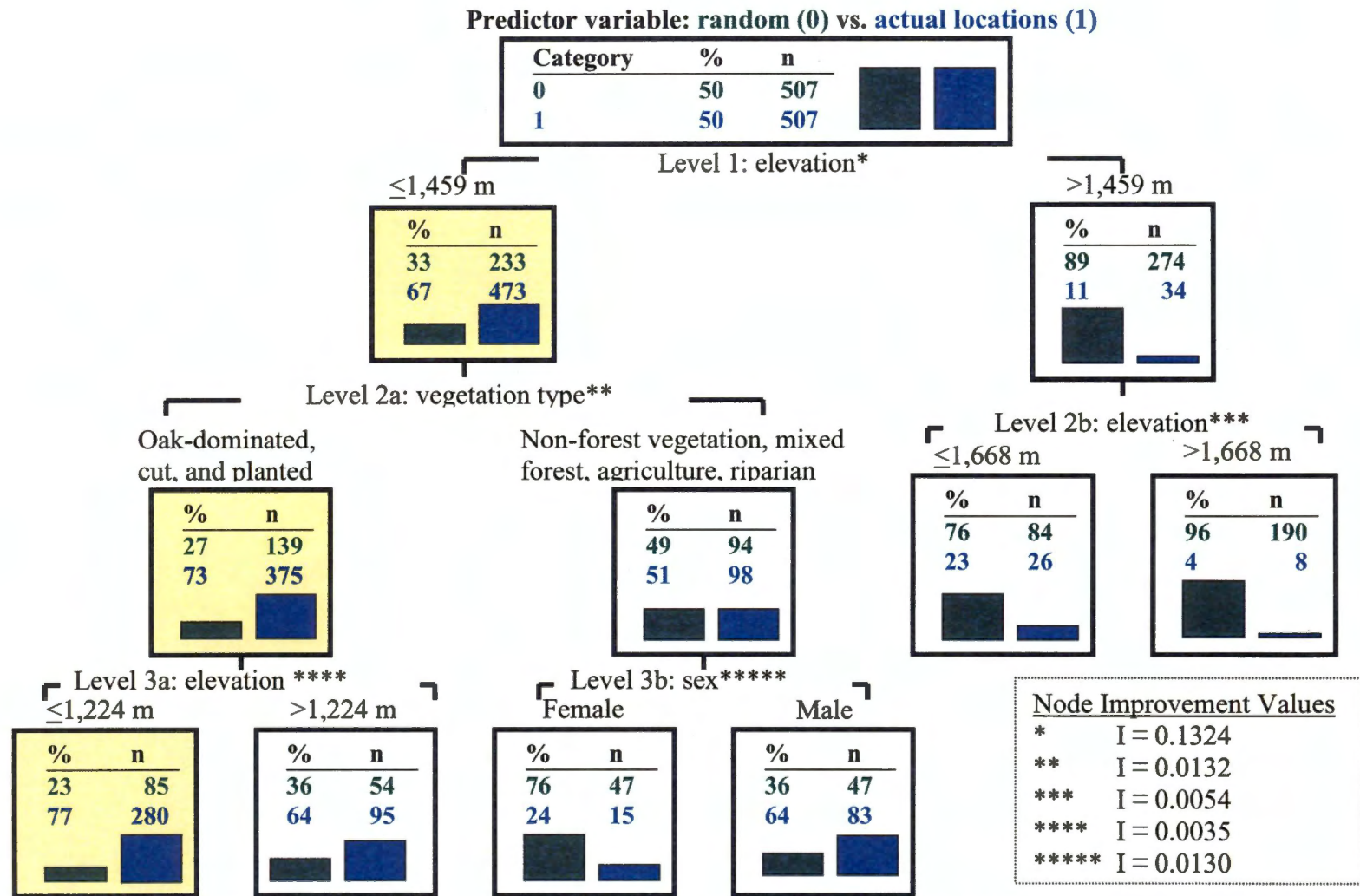


Fig. 4-5. Classification and regression tree model for habitat use of Asiatic black bears in Nagano Prefecture, Japan, 1997–99. Boxes with a yellow background are those with the greatest concentration of actual versus random locations.

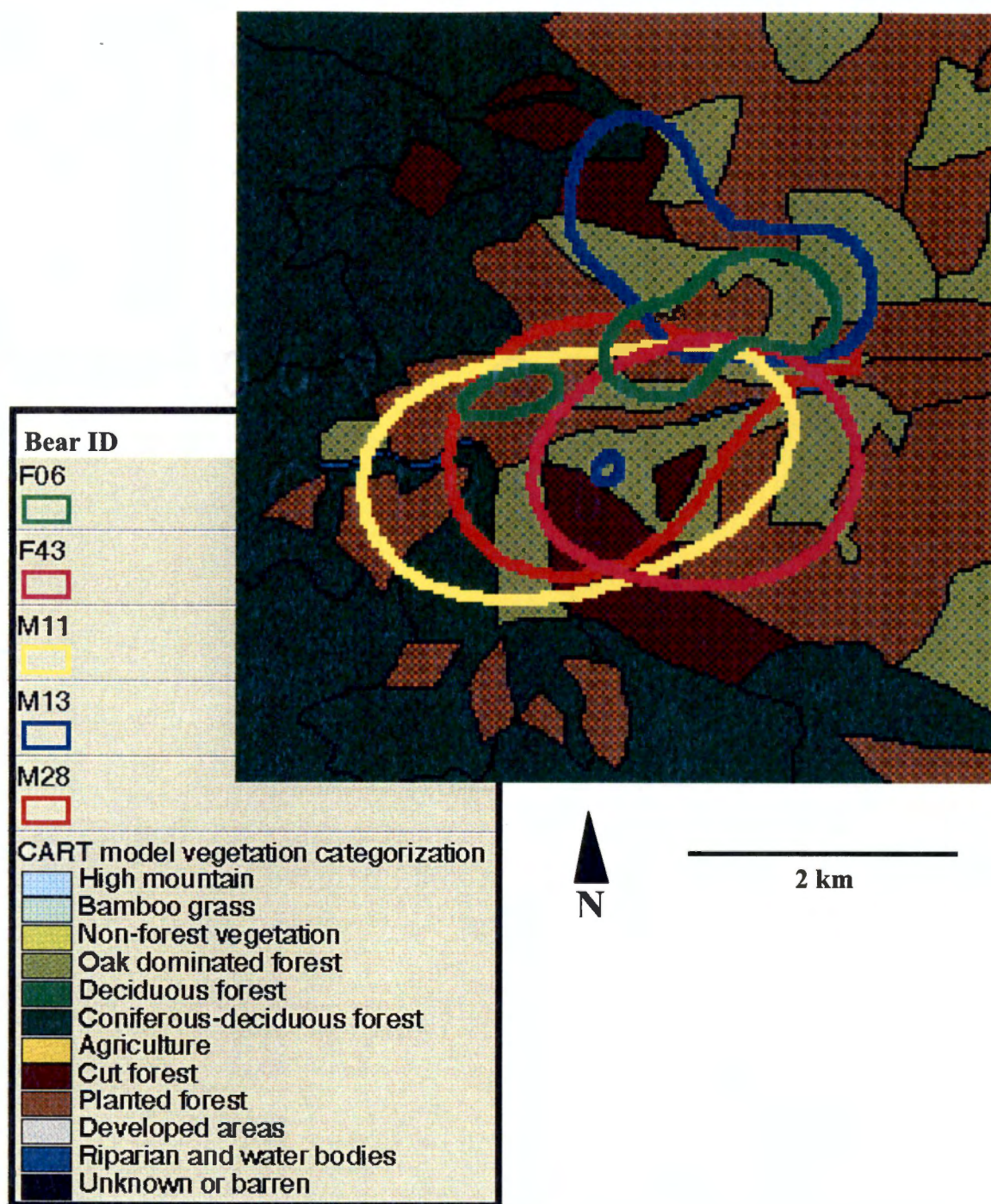


Fig. 4-6. Comparison of 50% kernel home ranges and the vegetation types for a classification and regression tree (CART) analysis to study the habitat use of Asiatic black bears, Nagano Prefecture, Japan, 1997–99.

Mahalanobis distance values for sample data points ranged from 1.8 to 291.4; the average D^2 value was 10.3 with a positively skewed distribution. D^2 values for all cells in the entire study area (432 km²) ranged from 1.7 to 436.8 (Fig. 4-7). D^2 values seemed highly correlated with elevation, vegetation type, and possibly distance to roads. Deciduous forests often had the lowest D^2 value and the 50% kernel contours often overlapped on forest patches of that type (Fig. 4-8). The highest D^2 values usually were in high altitudes, developed areas at low altitudes, or cut forests. Home ranges also overlapped on patches of cut forest, but those ranges also included deciduous forest (Fig. 4-9). Lower standard deviations of elevation, slope, and aspect in the model further indicated that they were most influential.

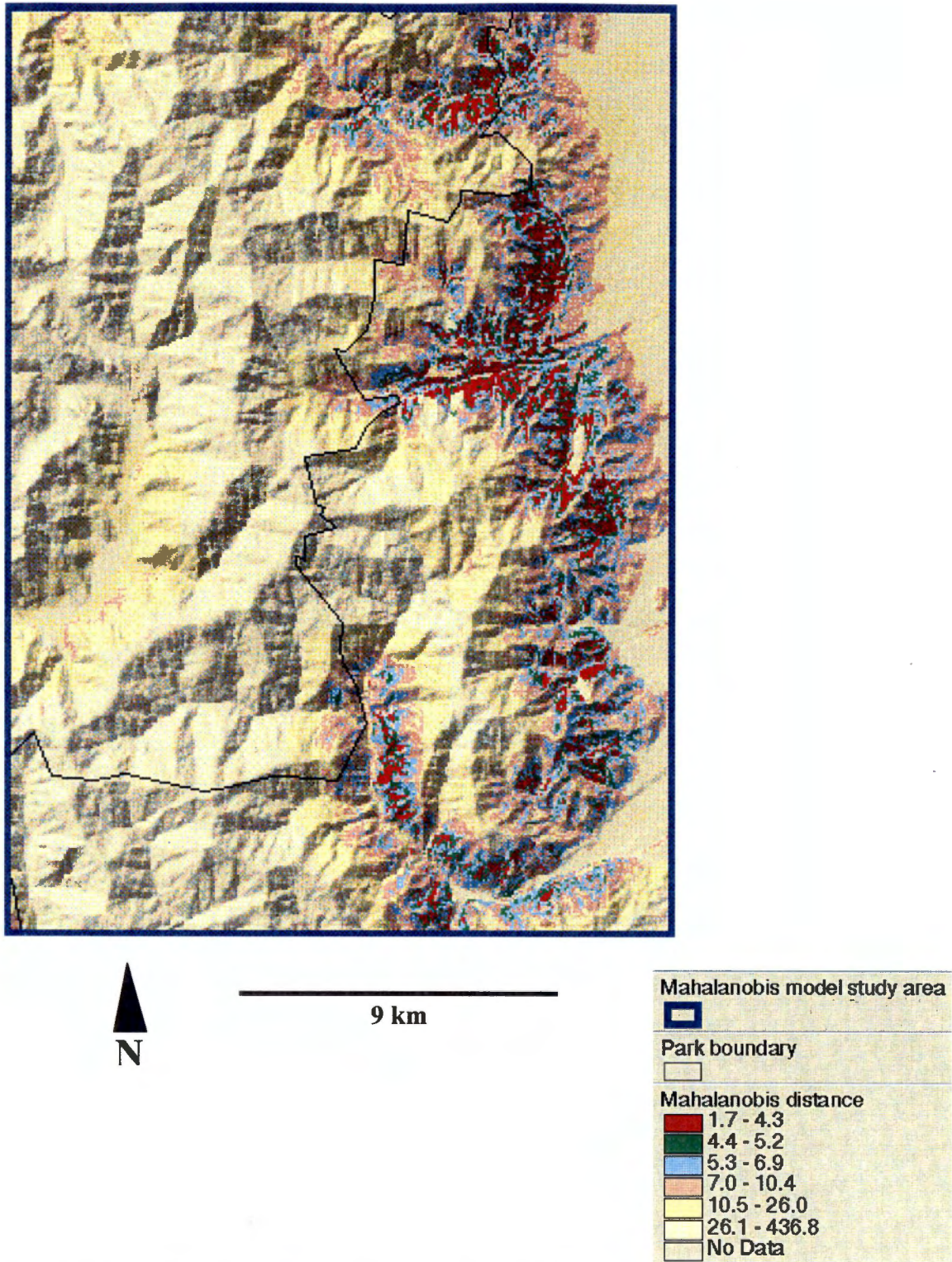


Fig. 4-7. Mahalanobis distance values to determine habitat use of Asiatic black bears in Nagano Prefecture, Japan, 1997–99.

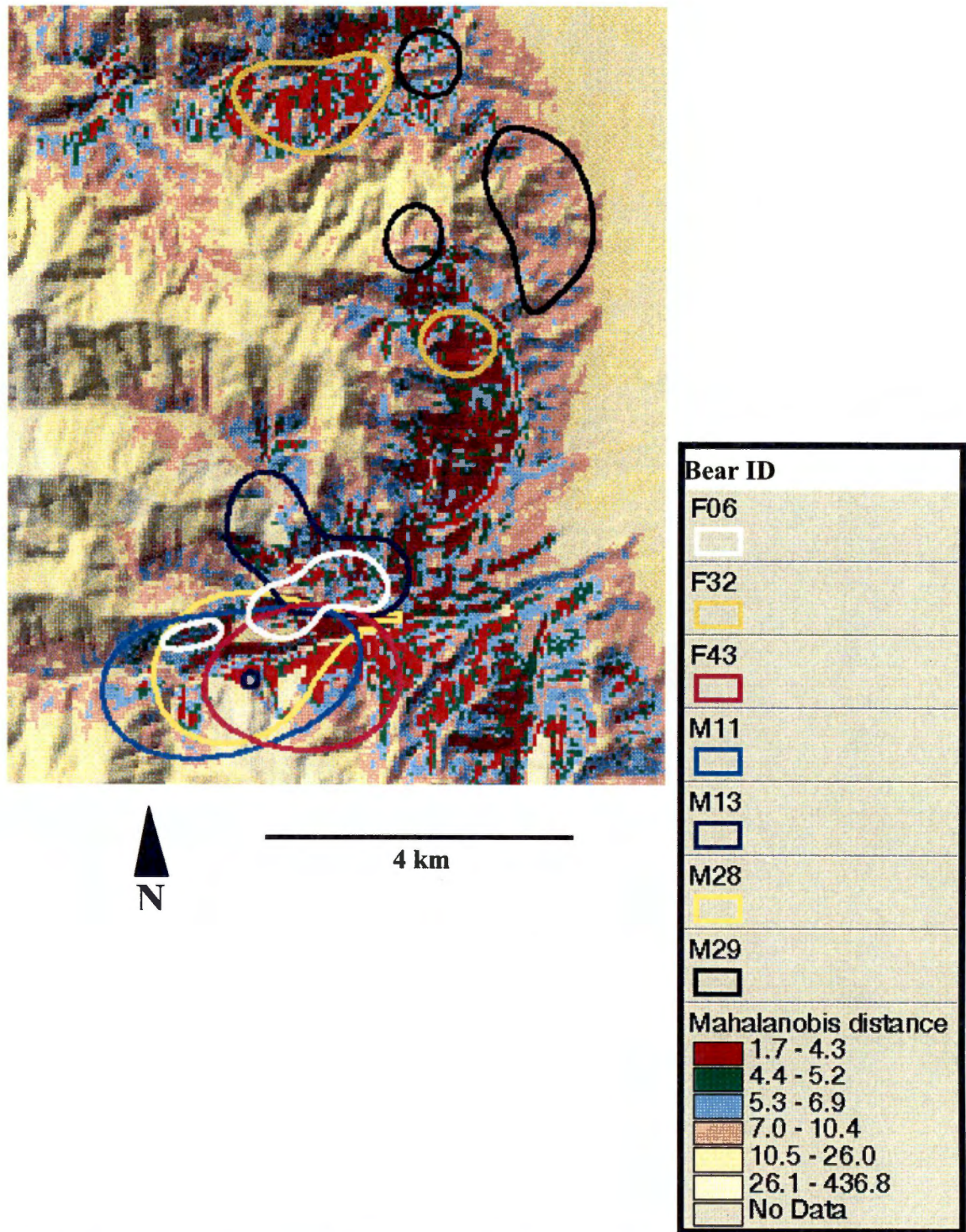


Fig. 4-8. Comparison of 50% kernel home ranges and Mahalanobis distance values to determine habitat use of Asiatic black bears, Nagano Prefecture, Japan, 1997–99.

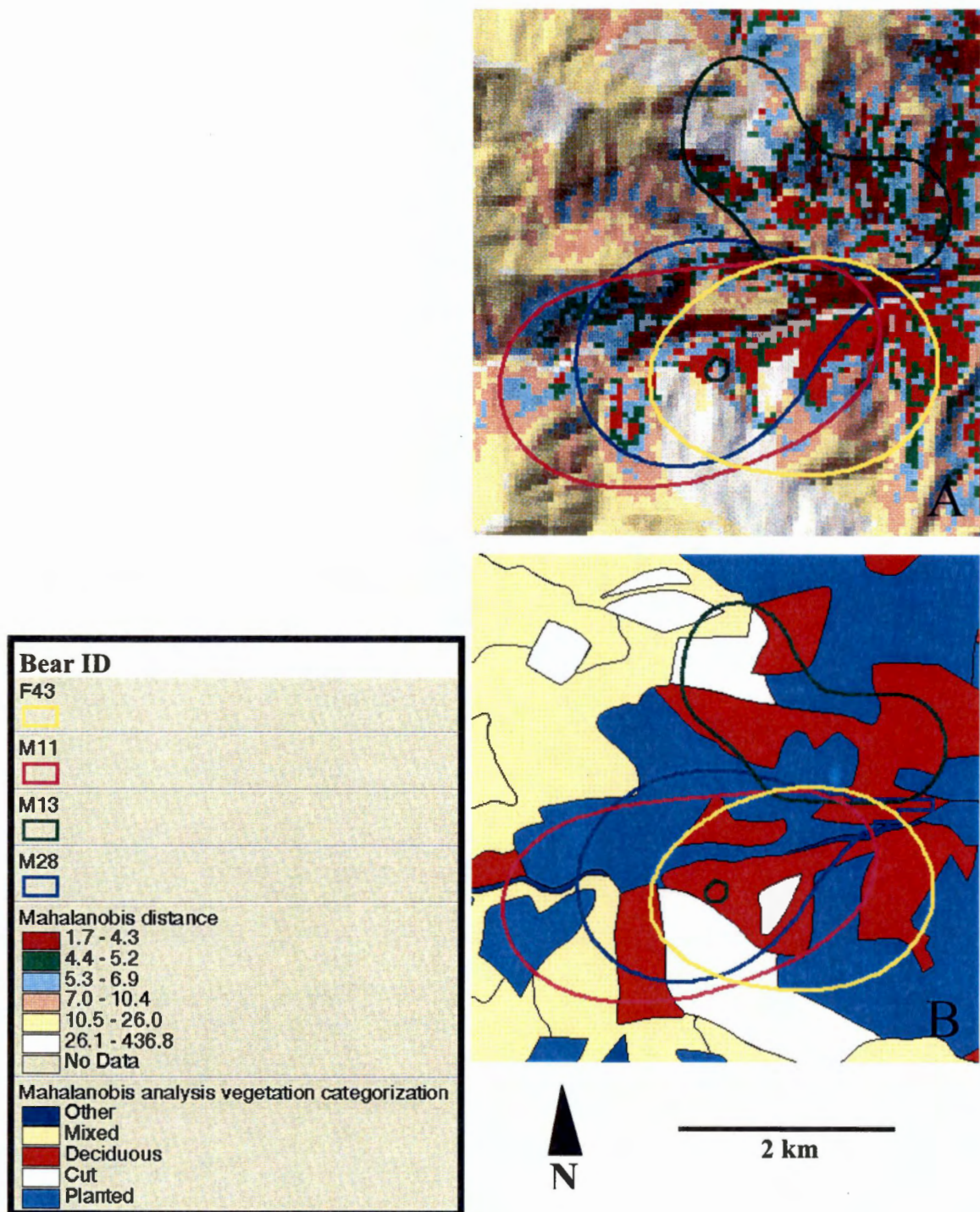


Fig. 4-9. Mahalanobis distance values (A) and vegetation polygons (B) compared with 50% kernel home ranges of 4 Asiatic black bears, Nagano Prefecture, Japan, 1997-99.

CHAPTER 5

DISCUSSION

CAPTURE AND HANDLING

Trapping efficiency of 47 trapnights per capture ($n = 10$) for this study was higher compared with trapping efficiency in Yamanashi Prefecture during the 1999 field seasons (155 trapnights per capture; $n = 18$ captures) (C. Angeli, Wildlife Management Offices – Fuji Station, personal communication). The greater inaccessibility of my study area may cause fewer disturbances by humans and possibly allow for a greater density of bears.

The skewed sex ratios of captured bears indicated potential sampling biases. In comparison, the ratio did not differ from 50:50 in a study in Hakusan National Park, Japan (Hanai 1980). The larger home ranges and greater movement of males may influence the differential capture rate. Consequently, the probability of males being captured increases (Clark 1991). An alternate hypothesis, proposed by Hanai (1980), is that a skewed sex ratio may be due to differences in hunting pressure.

Inclusion of locations on 2 bears (M19 and M38) trapped at nuisance sites also may have introduced bias. However, this bias appears to be negligible because most of the data were not associated with areas where incidents of damage were likely to occur. Additionally, these 2 bears did not have distinguishing characteristics of nuisance bears (McLean and Pelton 1990). Their weights were within the range of other bears and they had reached older ages (Table 4-2), despite the prevalent practice of managing bear damage with exterminations.

Ages were determined from 88 skulls of bears around Hakusan National Park (Hanai 1980). Although the sample was collected from harvest, the average age and the standard deviation for the Hakusan bears ($\bar{x} = 6.6$, $SD = 5.4$) was similar to our results ($\bar{x} = 6.5$, $SD = 4.7$, $n = 23$).

HOME RANGES AND HABITAT USE

Assessment of potential biases should be an integral part of any study. Researchers should recognize bias from techniques and from conditions inherent in the study area. Topography introduced bias by preventing continuous tracking of some bears, particularly those that used the alpine zone in the summer. I probably lost telemetry contact with some bears because of interference from the highly complex and steep terrain. Contact was permanently lost with some bears (M30, M47, and M51) and temporarily with most other bears. This would create bias in the habitat analyses if these bears were within undetected critical areas.

Moreover, dense patches of bamboo grass further exacerbated the problems associated with access. This restricted access forced me to relax the limitation on the time between azimuths to 30 minutes to ensure a data set of adequate size. The time limitation was necessary to reduce the effects of tracking bias. Other likely sources of telemetry error were animal movements, collar malfunctions, azimuth reading errors, and mistakes with mapping, data recording, and entry. However, the telemetry selection criteria reduced the sample size by approximately 66%, attesting to the efforts to reduce telemetry error. Moreover, the relatively large size of the vegetation polygons, the

variable concentrations of locations in forest type (e.g., 20 locations in cut forest, 188 in deciduous, 115 in mixed, 2 in other, and 182 in planted), and the relatively large pixel size of the elevation data also reduced the effect of telemetry error on the habitat analyses.

I censored data from 7 collared bears, released 7 bears without collars (2 before and 5 after handling) (Tables 4-1 and 4-2), and had limited coverage of the study area for trapping. Therefore, probably <50% of the bear population was included in my analysis. The bears that were not monitored may have used habitat differently than the bears that were tracked, so important aspects of the habitat use may be missed. For example, it appears that at least 25% of the bears used the alpine zone during the summer (O. Huygens, Shinshû University, personal communication), yet I only had a few locations in that zone after censoring. However, every tracked bear moved to the montane zone in the fall. Therefore, this analysis best represents autumn.

Location and size of home ranges observed in Asiatic black bears usually are attributed to distributions of food resources (Hazumi and Maruyama 1986; Ohsako 1995; Hashimoto 1998; M. Hwang, University of Minnesota, personal communication). Home range sizes of project bears were comparable to those observed in other studies of *U. t. japonicus* (Table 5-1), except for the results of other research projects in Japan summarized by Hazumi (1996). Hazumi reported the mean annual home range for males was 70 km² (60–110 km²) and for females was 40 km² (30–50 km²).

Table 5-1. Home range sizes for some populations of *U. thibetanus* and *U. americanus*^a.

Species	Location	Size (km ²)	Sex	Sample size	Reference
<i>U. t. japonicus</i>	Nagano Prefecture, Japan	10 24	F M	13	This study.
<i>U. t. japonicus</i>	Central Japan	26 66	F M	11 8	Hazumi (1999)
<i>U. t. japonicus</i>	Chichibu Mountains, Japan	1–5	B	Unk.	Hashimoto (1998)
<i>U. t. japonicus</i>	Tanzawa Mountains, Japan	33 101	F M	4 4	Hazumi et al. (1997)
<i>U. t. japonicus</i>	Summarized from various studies, Japan	40 70	F M	n/a	Hazumi (1996)
<i>U. t. japonicus</i>	Fukui Prefecture, Japan	20 33	F M	1 1	Ohsako (1995)
<i>U. t. japonicus</i>	Nikko National Park, Japan	13	B	6	Hazumi and Maruyama (1986)
<i>U. thibetanus</i>	Sichuan, China	27	B	2	Reid et al. (1991)
<i>U. americanus</i>	Cherokee National Forest, Tennessee, USA	14 146	F M	18 14	van Manen and Pelton (1996)
<i>U. americanus</i>	Great Smoky Mountains National Park, Tennessee, USA	5–71 25–1,102	F M	12 11	van Manen (1994)
<i>U. americanus</i>	Southern California, USA	17 22	F M	1 5	Novick and Stewart (1982)
<i>U. americanus</i>	Great Smoky Mountains National Park, Tennessee, USA	15 42	F M	12 8	Garshelis and Pelton (1981)
<i>U. americanus</i>	West-central Idaho, USA	18 105	F M	4 5	Reynolds and Beecham (1980)

^aSex: F = female, M = male, B = both sexes

Home ranges of female bears were smaller than those of males. Similar observations were made in other Asiatic black bear studies in Japan (Ohsako 1995, Hazumi et al. 1997) and for American black bears (Garshelis and Pelton 1981, Novick and Stewart 1982, van Manen 1994, van Manen and Pelton 1996) (Table 5-1). Harestad and Bunnell (1979) compared female and male home ranges of American black bears and observed a close correlation of body size and home range ratios. However, based on my study, and those of Hazumi (1996), and Hazumi et al. (1997), the ratio for weights of Asiatic black bears by sex (1.2–1.6 male:female) is smaller than the ratio of home range sizes by sex (1.8–3.0 male:female). Van Manen and Pelton (1996) observed a similar relationship in the Cherokee National Forest in Tennessee and they hypothesized that the proportionally larger home ranges of males were related to reproductive fitness, energy restrictions, and distribution of food resources. More specific research would need to be done to find support for any or all of these hypotheses for Asiatic black bears. The lack of statistical significance for the differences between the sexes and the valleys may be due to the small sample sizes and the overlap of values.

The home range estimates from this study must be interpreted carefully, because sections of some home ranges probably were not included when I censored a high percentage of locations. For example, the home range of M11 seems to be underestimated. Since 1997, M11 was found >3 times in an area about 3 km west-southwest of the home range area that I calculated. Underestimation of home ranges would be more likely in bears that used the alpine zone in the summer because those areas are less accessible.

The CART model indicated that habitat use is associated with elevation and vegetation type. Of the 507 locations, 375 were at or below elevations of 1,459 m in oak, cut, or planted forests. An additional concentration of locations was observed at or below elevations of 1,224 m. Concentrated blocks of low D^2 values also indicated that habitat use was highly correlated with those 2 variables, and with distance from roads. The low density and relatively low use of roads in the study area possibly allowed bears to be fairly tolerant of disturbances from traffic (Kasworm and Manley 1990, Beringer et al. 1990, Kasbohm et al. 1998).

As expected, areas with lower D^2 values corresponded with areas where home ranges overlapped (Fig. 4-8). The correspondence is shown by fixed kernel 50% contours that traced areas with concentrated D^2 values <5.2 . A few areas of high D^2 values did not have overlapping home ranges. This may indicate that there were bears within the study area whose home ranges covered these areas but were not captured.

Elevation, aspect, and slope had lower standard deviations than other variables, so they were the most influential variables in the model. These topographic variables, especially elevation and aspect, influence the distribution and development of plant communities. Therefore, the association of elevation and bear locations in both models may not demonstrate a direct relationship. Bear locations in this study area and in Nikko National Park were primarily in the montane zone (Hazumi and Maruyama 1987). Hazumi and Maruyama attributed this concentration of locations to the presence of oak stands at elevations from 800–1,600 m. The importance of oak in the montane zone also applied to my study area (O. Huygens, Shinshû University, personal communication).

Bears may move in response to elevation, because the reliability of food sources is good throughout that zone, particularly in the fall.

Another similarity with the Nikko study was the low use of the subalpine zone. Research on food habits in my study area resulted in 408 collected scats, but none were found at elevations between 1,760–2,450 m (O. Huygens, Shinshû University, personal communication), an altitude range within the subalpine zone. Approximately 25% of bears in the study area used alpine meadows during summer (O. Huygens, Shinshû University, personal communication). For example, M11 and M19 were observed feeding in alpine meadows. Biases associated with tracking difficulties led me to censor many locations in the alpine zone. Consequently, the Mahalanobis model (Fig. 4-4) indicated poorer habitat areas (large D^2 values) at high elevations. The low use of the subalpine zone reinforces the importance of managing the montane zone to conserve the species.

My results indicate seasonal changes for home ranges and habitat use by bears. Despite concentration of fall locations in the montane zone, most bears had larger home ranges during that season, possibly because fall food resources had a more patchy distribution. Movements were extensive during this season with some bears travelling to other valleys. Not only did bear movements seasonally change, but shifts in scat content also were observed in the study area (O. Huygens, Shinshû University, personal communication) and in the Tanzawa Mountains of Kanagawa Prefecture (Hazumi et al. 1997). Crop damage almost exclusively occurs in late summer and early fall in Japan

(Nagano Prefecture 1994), indicating that many bears return to natural food habits once hard mast becomes available.

Changes in seasonal movements seem to be related to the importance of acorns in the diet of Asiatic black bears (Hazumi and Maruyama 1986, 1987; Torii 1989; Ohsako 1995; O. Huygens, Shinshû University, personal communication). In the Mahalanobis model (Fig. 4-3), the best habitat often was associated with deciduous forests. Most patches of deciduous forests in the study area (>95%) had an oak species as 1 of the 2 dominant tree species (*Quercus mongolica* or *Q. crispula*). Bears in Tochigi Prefecture, an area north of Tokyo and northwest of the study area, exhibited a similar concentration of locations in deciduous forest (Hazumi and Maruyama 1987). These researchers found that bears showed no preference for any vegetation type in the summer, but used deciduous broadleaf forest more than expected in the fall.

Travel between patches of deciduous forest (Figs. 3-3, 4-3, and 4-4) seems to account for many of the larger home ranges, such as the southern extensions of the ranges of F43 and M11 to the Shima-shima Valley in mid-October 1999. These 2 bears and many others had main ridges (>2,000 m) in the center of their home ranges. Quality of the distant patches of food may compensate for the energy investment of crossing these ridges. Where resources are more continuous, such as the Great Smoky Mountains National Park, bears may not need to cross ridges to get adequate resources (Garshelis and Pelton 1981). Increase in home range sizes because of dispersed food resources has been observed among American black bears (Reynolds and Beecham 1980, Garshelis and Pelton 1981, van Manen and Pelton 1996). Additionally, overlapping home ranges, even

in areas with low trapping effort, were observed in many sections of the study area. Only 2 study bears (F37 and M38) had 50% kernel contours that did not overlap with those of other bears. Ranges often overlapped on patches of oak-dominated forest (Fig. 4-6). Core home range areas (50% contours) for several bears (F06, F32, F53, M13, and M49) were discontinuous (Fig. 4-8). Because of the importance of acorns in their diet and the dominance of oaks in the montane zone, these movements may be attributed to the food resources available in those patches.

The Mahalanobis distance model indicated that the lowest quality habitats were usually in cut forests. In cut forests, bamboo often dominates the understory, unless tightly controlled. Furubayashi et al. (1980) noticed increased levels of tree girdling in areas surrounding cut forests, possibly indicating a lack of food resources (Noble and Meslow 1998). Some home ranges included blocks of cut forest, which generally had lower D^2 values (e.g., the home range of M13 and near the overlapping home ranges of F43, M11, and M28) (Fig. 4-9). Patches of deciduous forest around such cut areas may provide adequate resources for bears. As forest management intensifies, bears may have to invest more energy to move between those patches. Therefore, management for bears may include selection of sites for timber extraction that will reduce the travelling distance between resource patches for bears.

The importance of planted forests was evident in both habitat models. Ohsako (1995) and Hazumi and Maruyama (1986) also observed that bears used coniferous plantations, along with deciduous stands. Hazumi and Maruyama (1986) hypothesized that plantations were used for cover. These areas also may provide sources of soft mast

(Campo and Hurst 1981), as seen in American black bears (Eiler et al. 1989, Meddleton and Litvaitis 1990). Planted forests may have good soft mast crops, compared with natural forests, because of increased light to the understory. The soft mast plants may be able to recolonize before bamboo grass outcompetes them or after the bamboo has been cut to promote commercial tree growth. Because bear habitat use and movements are influenced by different forestry management schemes, proper management techniques should be carefully considered in critical areas of the bear distribution.

Both habitat models indicated the importance of planted and deciduous forests, particularly oak forests, in the montane zone. These corresponding results increase the reliability of these analyses.

CHAPTER 6

MANAGEMENT IMPLICATIONS

Science-based management of black bears in Japan is constrained by the lack of a governmental wildlife agency. Two factors may explain why high-level Japanese government officials are not responsible for most wildlife management decisions. First, due to the elimination of the widespread influence of the emperor and decentralization of government power after World War II (Roy 1998), responsibility for wildlife is not clearly established (Hazumi 1999, Huygens 1999, Moll 1999). Second, most villages next to mountains have borders extending to the nearest major ridge, which creates narrow strips of ownership. Home ranges and territories of large mammals in Japan often cover more than 1 jurisdiction (Roy 1998, Hayashi et al. 1999). One village may use techniques such as electric fences and aversive conditioning, whereas its neighboring village may exterminate any bears that are caught. Within a village, these contrasting techniques may alternate every few years as new village officials are elected. So large mammals often inhabit areas that are in contrasting management regimes (Hayashi et al. 1999, Huygens and Hayashi 1999).

There is a connection between bear movements and the effect of management schemes. Availability of food sources influences movements of bears in North America. When natural food shortages occur, bears often move large distances (Garshelis and Pelton 1981, Rogers 1987, Smith and Pelton 1990). For Asiatic black bears in Japan, such movements often increase the probability of encountering developed areas, particularly as the forest-development interface moves deeper into the montane zone. As

a result, the number of depredation kills increases, in some areas surpassing the number of bears harvested by hunters. A landscape analysis for all of Nagano Prefecture (J. Yoshizaki, University of Tennessee, personal communication) indicated that agriculture strongly influences the bear distribution. However, future expansion of agricultural areas in Japan is unlikely because of the highly complex topography. Even if bears do not expand their ranges outside the mountains, they will have greater difficulty finding resources in the future because of the invasion of development from the valleys into the mountains. Because the rate of development in the mountains has increased (Roy 1998), there is greater urgency to promote wildlife management.

One of the most beneficial conservation activities would be more science-based management. Data on the effects of forest conversion and bear harvests are needed to set proper management goals and ensure that the bear population survives the long-term impacts of habitat destruction. As we have already seen in the study area, some government offices and individuals are willing to try alternative methods (Hayashi and Huygens 1998), but they need support, especially information. The future of Asiatic black bears in Nagano and other areas in Japan is critically dependent on science-based management. Although the topographic complexity of the terrain in Nagano Prefecture probably has allowed bears in the interior mountains to be a population source (Kontio et al. 1998), the long-term status of the population is questionable, as long as uninformed decisions are made.

SUMMARY

1. I studied home ranges of bears and the bear-habitat relationship in the Northern Japan Alps, Nagano Prefecture, Japan, 1997–99.
2. I cooperated with the Shinshû Asiatic Black Bear Research Group and captured 28 bears 33 times.
3. Twenty-one bears were tracked for location and habitat use analyses.
4. Average home range size was 18.7 km^2 ($n = 13$); 10.0 km^2 for females and 24.2 km^2 for males, based on the minimum convex polygon method. Based on the fixed kernel method, the average home range sizes for the 95%, 75%, and 50% contours were 24.2 km^2 ($SD = 15.1$), 20.4 km^2 ($SD = 7.4$), and 8.4 km^2 ($SD = 3.2$) ($n = 7$), respectively.
5. I analyzed habitat use with a classification and regression tree (CART) analysis. Bears used oak and planted coniferous forests in the montane zone more than expected.
6. I also developed a habitat model in GIS using the Mahalanobis distance statistic. Areas with high quality values for the habitat index were usually associated with planted forests and deciduous forests, dominated by oaks that are a source of hard mast. Planted forests likely provided cover or soft mast. Cut forests were of low habitat quality.
7. Management of wildlife and forestry resources based on scientific research may contribute to the health of the Asiatic black bear population in Japan.

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