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Black Bear Population at the Mountain Road Construction Area in Chichibu, Central Japan

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Introduction

Construction was carried out on a portion of the national road Route 140 in the Chichibu mountains, Saitama, central Japan throughout the 1980s and 1990s. The section of interest passes through a steep mountainous area covered with well-reserved natural temperate forest whithin University Forest in Chichibu, the University of Tokyo (ISHIDA *et al.*, 1991; ISHIDA *et al.*, 1994; UFUT, 1998). Because of the high levels of biodiversity in the area, the impact of that road construction and traffic has had on the forest ecosystem, and animal populations has been a topic of interest.

The University Forests, the University of Tokyo (UT) received trusts to conduct the nature surveys in relation to the construction of Route 140 in 1986–1997 from Ministry of Construction and later in relation to the traffic from Saitama Prefecture government. The author conducted a 10-year ecological survey as a part of this research project in between 1990–1999. The intimate objective of this study was to estimate the presence of habitat fragmentation due to Route 140, with respect to large mammal populations (ISHIDA *et al.*, 1991), by interpreting the actual data on black bear population in this area (ISHIDA *et al.*, 1994).

The black Bear (*Ursus thibetanus japonicus*) is a largest and common mammal in the broad-leaf deciduous forests in central to northern Honshu Island, Japan, and small populations have been extinct or threatened in western Japan (HAZUMI, 1996; ISHIDA, 1995). The species is sometimes thought of as a symbol of forest biodiversity.

The Black bear is a "phytophagous carnivore" adapted to seasonally and unpredictably changing resources, and its breeding is believed to be strongly dependent on the masting mainly of beech family trees in central Japan (ISHIDA, 1995). The mortality of adult bears is supposed to be an important factor in population extinction by the demographic simulation by MIMURA and HORINO (1999). Each individual of an animal not always behaves for the fittest for the population survival or reproduction, and population fragmentation can have a significant affect on the population (MATSUDA and ABRAMS, 1994; ISHIDA, 1995). The road has two short and one six-kilometer long tunnels in this area, that are expected to function as a kind of corridor for bears, which may decrease problems of population fragmentation by Route 140. To learn about bear population condition and the affect by Route 140, we need to estimate their density, home range sizes and location, and demographic parameters.

Although the presence of bears in their main habitat of natural broad-leaf deciduous forests with nut and acorn trees can be confirmed by the field sign such as fecal droppings, claw marks on tree trunks and feeding platforms in the tree crowns, direct observation of the bear in nature is almost impossible, as they usually quickly and quietly escape human beings in the natural habitat. Thus the capturing of bears is necessary to effectively survey

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ecology and population parameters. In this study we obtained some density and home range estimates, capturing bears and marking them with ear tags, microchips and radio-transmitters.

Study Area

The study area is located in the western part of Ohtaki Village, westernmost Saitama, called Oku-Chichibu, central Japan. It is near the border of four neighboring prefectures, Tokyo, Yamanashi, Nagano and Gumma (Fig. 1). There are two large valleys in the main research area, Takikawa and Irikawa Valleys. The national Road route 140 has constructed on the northern slope of the Takikawa Valley and there is a small and unpaved mountain road of the University Forest in Irikawa Valley. The structure of the national road is supposed to be a barrier of many mammals to cross and its traffic might be more, but the university forest's road is small enough or traffic is well restricted not to disturb them (ISHIDA, *et al.*, 1991). The Paleozoic and Mesozoic bedrock is hard and has been scraped away by erosions over a hundred million of years. As a result, the slope within the area is steep especially close to the bottom of main valleys of Takikawa and Irikawa, and at the entrance of their branch valleys (ISHIDA *et al.*, 1993).

A significant amount of primitive and secondary old broad-leaf natural forest remains in the study area, which covers more than 80% of the university forest (ISHIDA *et al.*, 1993). The elevation of the study area is from about 600 m to 2,000 m. Black bears spend most of their time in the cool temperate deciduous forest and mixed forest below 1,500 m (ISHIDA, personal observation on field sign).

About 160 species of trees have been recorded in the University Forest in Chichibu, UT. The vegetation diversity is high as a result of a large range in elevation and complex terrain with rich rain fall (UNIVERSITY FORESTS, 2001). Most of the area is covered by second growth deciduous forest of oaks (mainly *Quercus crispula*), beech (*Fagus crenata*), japanese beech (*F. japonica*), chestnut (*Castanea crenata*), maples (*Acer* spp.), cherry trees (*Purnus* spp.) and a mix of other species. The proportions of species vary from place to place. The dominant tree species are beech and japanese beech on the slopes, hemlock (*Tsuga sieboldii*) and fir (*Abies firma*) on the ridges, and senwood (*Fraxinus spaethiana*) in the rocky valleys. Other species present that provide food for bears include vines of wild grape (*Ampelopsis*

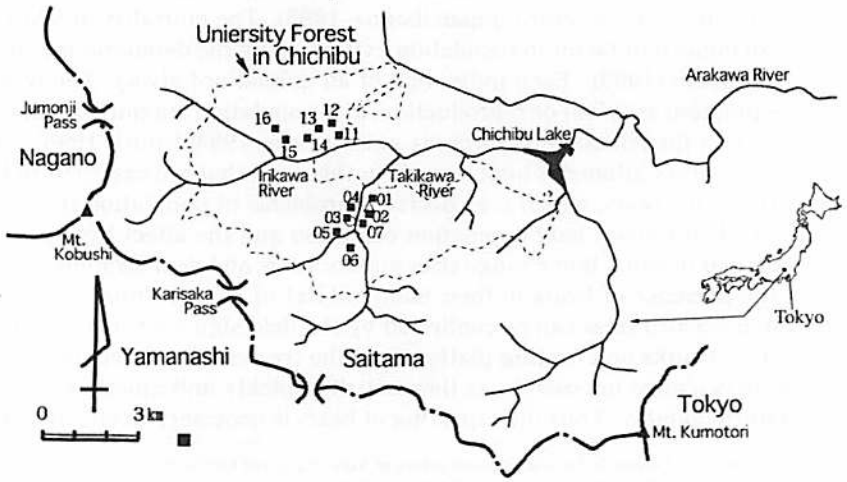

Fig. 1. 13 Locations of the study area and the bear traps (15 traps at 13 sites).

brevipedunculata), arguta (*Actinidia arguta*), and bushes of rasberries (*Rubus* spp.), etc. Nuts and acorns of beeches, oaks and chestnut trees are important food for the bear (HASHIMOTO, 1995). Although nuts and acorns are characteristic for their large and irregular annual fluctuation of crops or masting (KELLY, 1994; MIGUCHI, 1996), in this area the four main species' (*F. crenata, F. japonica, Q. crispula and C. crenata*) masting are not always synchronized, thus allowing for less fluctuation in the food resources for bears compared with other areas on Honshu Island.

Method

We set 15 bear traps at 13 sites (Fig. 1, Table 1). Traps were made of two or three oil barrels attached to each other and a beehive with bees and honey was set inside as the bait. The trap was configured so that the bear triggered the larch on the front door, allowing it to close, when it attacked on the bait (ISHIDA, *et al.*, in preparation). Seven traps at seven sites were set in the Takikawa Valley around route 140, and the others in the Irikawa Valley. With this trap allocation we supposed to catch bears from two areas, the national road and the wild, for comparison. We initially attempted to capture bears from mid April to mid December between 1990 to 1992, and later only during July, August and early September, from 1993 to 1999. The trapping period was shortened to those seasons in the latter seven years, because almost all bears were caught during the summer in the former years.

Table 1. 13 Barrel trap locations

Area	Trap #	Site name	Terrain	Altitude (m)
Takikawa*	01	Kudonosawa	Slope	900
	02	Migurosawa	Ridge	780
	03	Takadaira	Slope	1000
	04	Namesawa	Ridge	1000
	05	Wasabizawa	Slope	1120
	06	Sawagoya	Slope	1150
	07	Takadairataigan	Slope	900
Irikawa	11	Iriyama	Ridge	1000
	12	Yatake	Slope	1100
	13	Toyaone	Slope	1100
	14	Horiwari	Slope	1140
	15	Akasawa	Ridge	1180
	16	Akagisawa	Ridge	1220

* The national road Route 140 was constructed in the Takikawa area.

Numbered ear tags were attached all the trapped bears. Microchips (Trovan Limited, Germany) were also implanted inside the skin beyond the right ear of the bears captured from 1995 to 1999. We also fitted collar mounted VHF radio-transmitters (ATS and Telonics Corporation, USA) on larger individuals.

We roughly located bears fitted with radio-transmitters determining the direction and strength of the wave with Yagi and/or rod-anntenas, and noting the presence or absence of ridges as barriers or reflectors of the radio wave. This combination of information was used to home in on the location to a small valley or a ridge, around which a circle of a hundred meters in diameter was recorded. Annual home ranges were estimated by drawing an outline of all location points and/or circles.

Results

Capture of Bears

Twenty-two females and 36 males were caught 136 times, during nine trapping seasons. No bear were caught in 1990. We captured three bears in 1991, nine in 1998 and five in 1999. From five to seven females and six to ten males were captured 18 to 24 times, each year, between 1992 and 1997. After 1993 recaptured bears were caught every year and in

Table 2. Number of bears of captured and recaptured each year in the two areas

Year	Takikawa*1		Irikawa		Total*2
	nwcp	recp	nwcp	recp	
1990	0	—	0	—	0
1991	3	—	0	—	3
1992	6	0	10	0	16
1993	2	2	4	5	13
1994	5	3	3	3	14
1995	5	3	2	4	14
1996	0	6	6	5	17
1997	3	3	3	5	14
1998	3	3	2	1	9
1999	4	1	0	1	6

Abbreviations, nwcp=newly captured; recp=recaptured; (in annual record, in each area)

*1 The national road Route 140 was constructed in the Takikawa area.

*2 Individual numbers of each year. As there were bears caught in both area at one year, the total number is not the same as the sum of the left four columns.

Table 3. Number of bears of each sex caught in each area

Year	Takikawa*		Irikawa	
	Fem.	Male	Fem.	Male
1990	0	0	0	0
1991	2	1	0	0
1992	4	2	3	7
1993	4	0	3	6
1994	5	3	2	4
1995	5	3	1	6
1996	2	4	3	8
1997	3	3	4	4
1998	1	5	1	2
1999	3	1	1	0

Abbreviations, Fem.=female

both areas (Table 2), and which I assumed to indicate minimum capturing bias.

More males than females were caught (Table 3), mainly a result of differences in the number of immature bears captured, five females (<30 kg) and 16 males (<40 kg) in total. The sex ratio of trapped adult bears was almost equal every year. The exception was that of the Takikawa area in 1993, when no male was caught (Table 3). This result suggests that the density of the male bears is the same as that of females.

The numbers of bears captured in the Takikawa and the Irikawa areas did not differ significantly between sexes or among years, with the exception of no males captured in 1993 in the Takikawa area. The number of females captured in the Irikawa area was smaller than that of males in 1995. However that seemed to be partly caused by the repeated capture of two small juvenile males, nine times, and the resulting decrease in trap availability in the Irikawa area for that year.

Home ranges and density

We fitted 23 individuals 34 transmitters. The movement of 16 individuals was traced continuously from two to six years. Dispersal of two males was confirmed by hunting reports from remote areas in 1995 and 2000.

The outlines of the home ranges of six, eight and seven female bears in 1994, 1995 and 1996 are shown respectively in Figs. 2–1 to 2–3. All of these female ranges are overlapped or touched each other. Thus I supposed that all the breeding female bears were monitored with radio transmitters during those three years. Dividing the total area of these ranges by the number of them, we estimated the average female density to be about one bear per 7 to 8 square kilometers. Range sizes were similar between the Takikawa and the Irikawa areas. The main valleys of Takikawa and Irikawa functioned as borders for female home ranges, probably because of the very steep slopes along the bottoms.

The home range outline of male W1 encompassed an area of 60 square kilometers in 1991–1992, and 14 square kilometers in 1993. Accurate estimates on the home range sizes

and locations of the other males or for the same male in the other years were not available because they often crossed the main valleys and ridges of the study area, moving to areas inaccessible to radio-tracking.

Male S26 was caught at Iriyama site and fitted with a radio-collar (Table 1 and Fig. 1) on July 14, 1992, and recaptured at Takadaira site, about three kilometers away on July 24. It was tracked around the Takikawa area until September 18 of the same year before contact was lost. We learned later that S26 was shot at Ichinose, Yamanashi, about nine kilometers far from the second capture site at Takadaira, on October 12 (Fig. 3). Although 1992 was a poor crop year for all nuts, acorns and other fruits in the Oku-Chichibu area, there were many oak trees with partly fruited acorns at Ichinose (Ishida, personal observation), likely contributing to the far-ranging movements of S26.

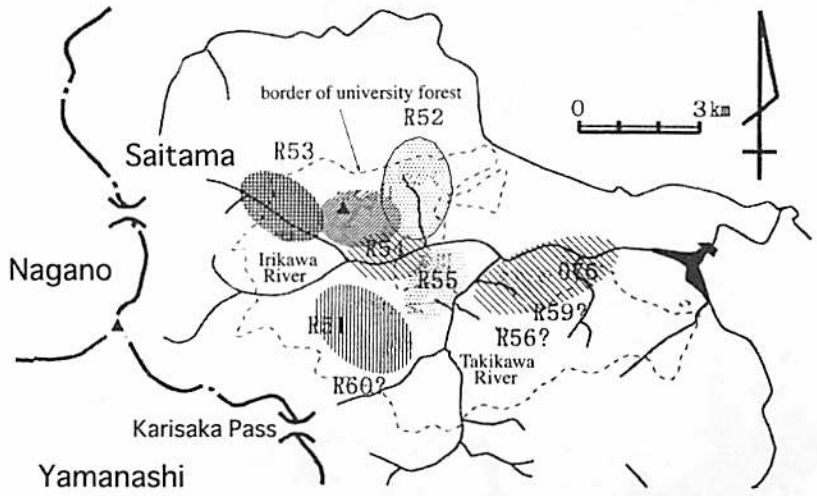

Fig. 2-1. Female home range outlines, 1994.

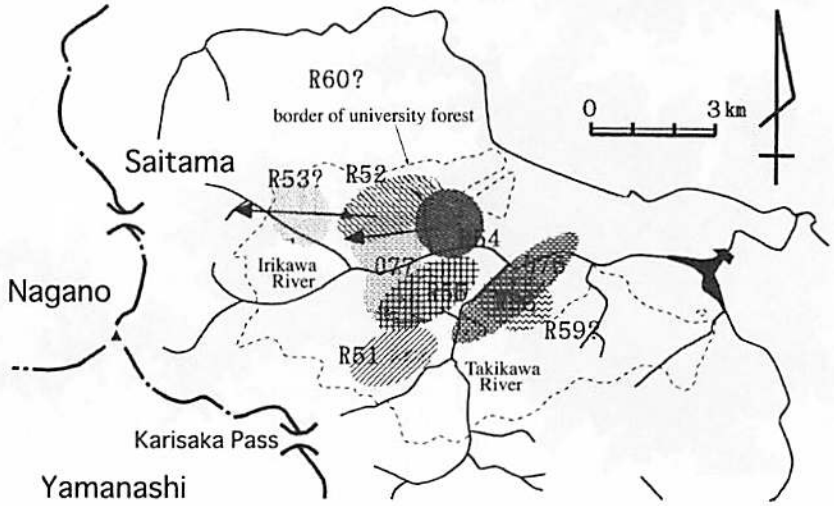

Fig. 2-2. Female home range outlines, 1995. Arrows indicate the movement for denning.

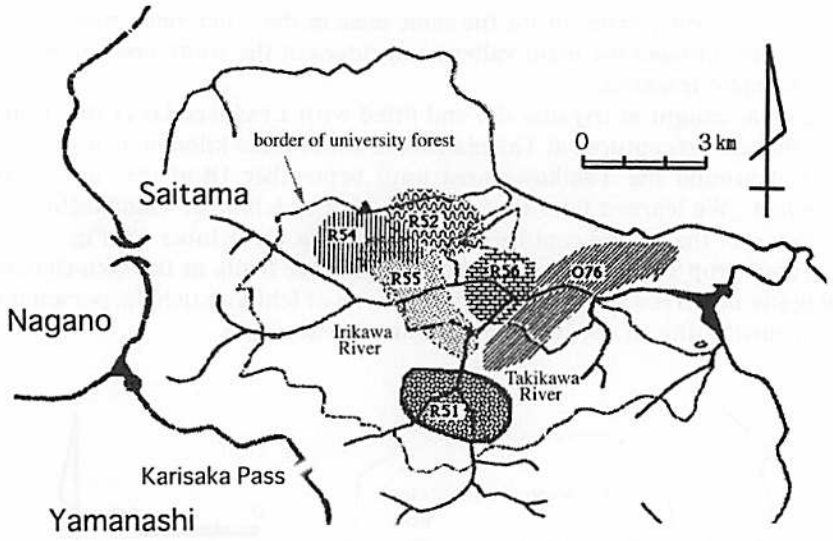

Fig. 2–3. Female home range outlines, 1996.

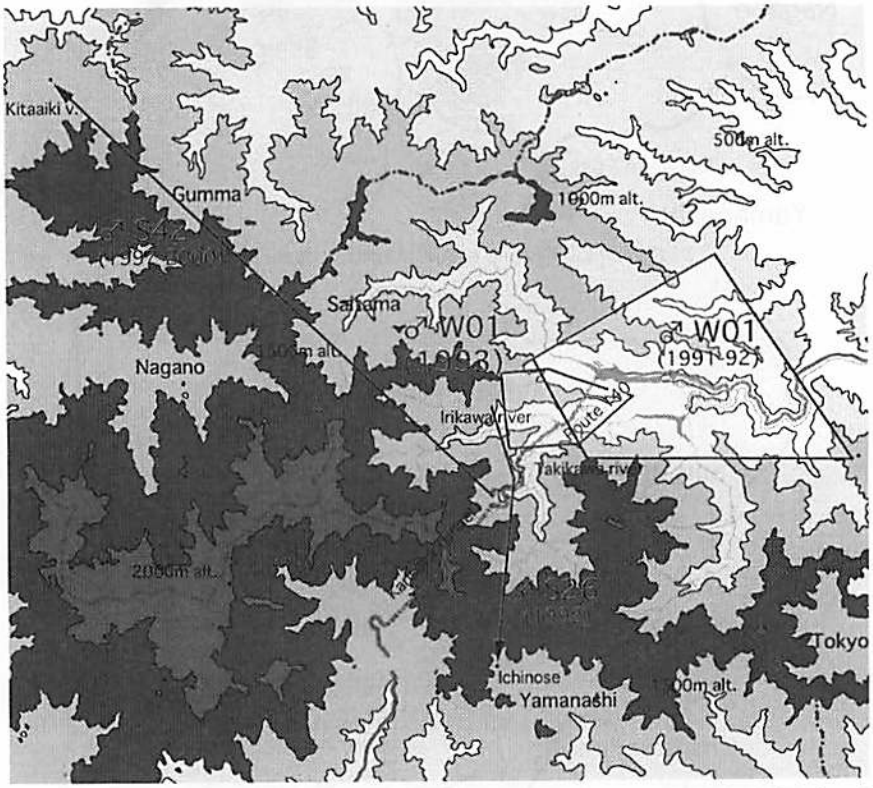

Fig. 3. Male W1 home range outline and the large distance movement records of males S26 and S42. Location of the national road Route 140 is also shown.

Another male S42 was reported to have been shot at an apirary of Japanese native bees in Kitaaiki Village, Nagano, about 25 kilometers from Oku-Chichibu, in August 12, 2000 (Fig. 3). S42 was last captured at Wasabizawa site (Table 1 and Fig. 1) on July 19, 1997. There was a mountain range of about 2000 m in altitude between the capture area and kill site in both cases.

Black bears mostly inhabited broad-leaf forests. However we do not have data of the ratios of vegetation preferences, because we could not locate their position exactly in our study area.

Discussion

Trapping results indicated that the density of the Japanese black bear in Chichibu is high, with one breeding female per 7 to 8 square kilometers. It is hard to suppose that the density had been much higher before the beginning of the construction of Route 140. The high density seemed to be maintained at least until the study period.

The lack of male captured at the Takikawa (Route 140) area in 1993 and the recovering by immature males captured in the following years, suggests an indirect fragmentation effect of Route 140, interpreted as follows. It was a poor crop year of nuts and acorns in this area in the autumn of 1992, and male S26 was documented to have been shot by a hunter about nine kilometers from the area. Other unmarked males from the study area might be met a similar fate. Some adult males were present in the Irikawa area in the following year, probably because that area was connecting to the north, much larger and continuous bear habitat. It might have taken a couple of years for adult males to recover in the Takikawa area, which is partly bordered by Route 140 to the north. If the assumed description above is true, this observation indicates a part of larger scale hunting pressure can affect the local sub population structure, at least temporally. Male black bears move large distances of ten, twelve or more kilometers, probably constantly, monitoring food resources and female bears.

Usually active males would be considered to play more positive roles in reproduction, however active males should have more chance to be a target for hunters. On the other hand, less active males with negative behavior would contribute less in reproduction, and less active males should have little chance to be killed by hunters. The decrease of active male proportion in a population would lead a further decrease of reproductive rate of the whole population. Matsuda and Abrams (1994) proved the possibility that such a mechanism can exist by a mathematical model simulation. Miura and Horino (1999) indicated that hunting pressure on adults can be the most significant factor to cause a decrease in population size and an increase in the extinction rate of the black bear populations.

No direct negative effect due to road construction and/or traffic, such as declining density or activity around the road, or successive effects on the bear population structure, such as a lack of mature individuals around the road for a long period, could be detected. Although Route 140, structured on a steep slope, acts as a strong barrier to movement for wildlife, thus fragmenting their habitat (Ishida *et al.*, 1991), the author thinks that the two small tunnels and the six kilometer long Karisaka Tunnel within the study area function as corridors for wildlife to cross the road, thus alleviating complete fragmentation. Providing such large-scale corridors is important to conserve large mammal populations.

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Summary

To estimate the effect of national road Route 140 construction on the black bear population, bears were caught with barrel traps with a bait of beehive in the two neighboring areas of Takikawa and Irikawa Valleys in Chichibu, Central Japan.

The body sizes were measured and the body conditions recorded. A part of larger adult bears were fitted a collar transmitter and their home rages were traced roughly. 58 individuals were caught in 136 times and 34 transmitters were fitted on 23 individuals during the 1991–1999 seasons.

Average density of breeding female was estimated as one bear per 7 to 8 square kilometers for six to eight individuals within the research area in 1993, 1994 and 1995. In Takikawa (Route 140) area no adult male was caught in 1993 and only a few immature males in 1994. One adult male was killed by a hunter about nine kilometers far from the research site within ten days since it left the area in October 1992, when the crops of the trees were all poor.

It is supposed that the Route 140 construction partly and temporally delayed the recovery of mature males in the area and the tunnels along the Route 140 act as corridors.

Key words: automobile road, habitat fragmentation, Japanese black bear, hunting, food resource

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東京大学秩父演習林の国道140号線施設地域における ツキノワグマ個体群の生息状況

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要 旨

東京大学秩父演習林の中に開通した国道140号線の施設が, 演習林とその周辺のツキノワグマ個体群に与える影響を評価するために, 隣り合う滝川流域と入川流域において, ミツバチを誘引餌としたドラムカン製捕獲器でクマを捕獲した。

捕獲個体の体重や体調を記録した。大型個体には首輪式の発信機を装着して, 行動圏を調べた。1991年から1999年の主に夏季にツキノワグマの58個体を136回捕獲し, 23個体の成獣に34個の電波発信機を首輪で装着して行動圏を調べた. 1993年から1995年における行動圏の調査結果から, 調査地で繁殖していたと推定される6〜8頭の雌の成獣は7〜8平方キロに1頭ていどの密度で生息していると推定された. 調査地内で秋の堅果がすべて凶作の1992年に, 発信機を装着した雄の1頭が直線で約9キロ離れた塩山市一ノ瀬で射殺されたことが確認され, 1993年には国道周辺の滝川地域で雄の成獣が1頭も捕獲されず, 1994年には同地域で未成熟の雄が捕獲されただけだった.

国道140号線が施設されていたために滝川流域での雄の成獣の生息個体数の回復が遅れた可能性があると考えられた。演習林内にあるトンネルが生息地の分断効果を和らげる重要な機能を持つことを示唆した.

キーワード: 自動車道路・生息地分断・ツキノワグマ・狩猟・食物資源