HOME RANGE AND HABITAT USE OF BROWN BEARS IN THE SOUTHWESTERN OSHIMA PENINSULA, HOKKAIDO

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Abstract: Movement, home range, and habitat use of 10 (7 M and 3 F) brown bears (*Ursus arctos yesoensis*) were investigated by radiotracking in southwestern Oshima Peninsula, Hokkaido, from May 1987 through May 1990. The annual home-range size was 28.1-39.1 km² for 1 female. Male home-range size was larger than that of females, although no males were monitored throughout the year. Lower deciduous natural forest areas such as beech-oak (*Fagus crenata*)-(*Quercus monoglica* var. *grosseserrata*) forest and maple-linden (*Acer mono*)-(*Tilia japonica*) forest were used by bears intensively, but subalpine areas such as sasa-birch (*Sasa kurilensis* or *S. senanensis*)-(*Betula ermani*) forest and sasa community were rarely used and usage was restricted. Food availablilty could influence the habitat selection by the bears.

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Hokkaido brown bears have been killed indiscriminately for more than 120 years. Especially during the period of 1966 through 1989, the spring prophylactic killing system was in force, and many bears were killed as pests and as game animals. Forest and field areas have been developed without considerations of bear habitat maintenance. As a result of these pressures, conspicuous extinction or near extinction had occurred by the 1980s in northern Hokkaido (Aoi 1990) and in areas such as the Shakotan Peninsula and the Yoichidake-Eniwa mountain area (Hokkaido Government 1986). However, recent bear damage to livestock and crops still occurs in other parts of Hokkaido (Hokkaido Government 1986). It is obvious that with the control kill alone, damages will continue to occur until the bear population drops to near extinction.

Since mid 1970, about one-fourth of the total brown bear damage in Hokkaido has occurred (annually) in the Oshima Peninsula (Hokkaido Government 1986), which occupies only about 9% of the island. As this area is a peninsula, characterized by having a very long boundary between bear range and human residential areas, troubles and conflicts between people and bears are apt to occur. Moreover, habitat development on the Oshima Peninsula could have a major influence on bear habitat and population maintenance on Hokkaido. Biological information such as brown bear home range and habitat use is required for proper habitat management.

The first successful brown bear radio-telemetry study in Hokkaido, Japan, was initiated in southwestern Oshima Peninsula in 1987. In this paper, I present preliminary information on movement, home range, and habitat use of Hokkaido brown bears in the deciduous forest of this area.

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STUDY AREA

The study area occupies about 300 km² and is located in the northwestern part of Mount Daisengen, which is the highest mountain of the southwestern Oshima Peninsula (Fig. 1). Elevation ranges from sea level to the top of Mount Daisengen, 1,072 m. Most of this area is steep mountain ranging between 200 and 600 m in altitude. Maritime temperate climate brings annual precipitation of about 1,209 mm and average temperature of -1.2°C in February and 22.2°C in August, in Esashi, which is located on the sea coast 10 km north of the study area (Japan Meteorological Agency 1983). Snow cover remains from mid December to late May in the higher area and from late December or early January to early April in the lower area along the sea coast.

The natural vegetation of the major part of the study area is forest dominated by beech (*Fagus crenata*), mixed with maple (*Acer mono*), linden (*Tilia japonica*), oak (*Quercus monoglica* var. *grosseserrata*), and dogwood (*Cornus controversa*), with under cover of sasa bamboo (*Sasa kurilensis* or *S. senanensis*), castor aralia (*Caphalotaxus harringtonia*), and spice bush (*Lindera umbellata* var. *membranacea*). This

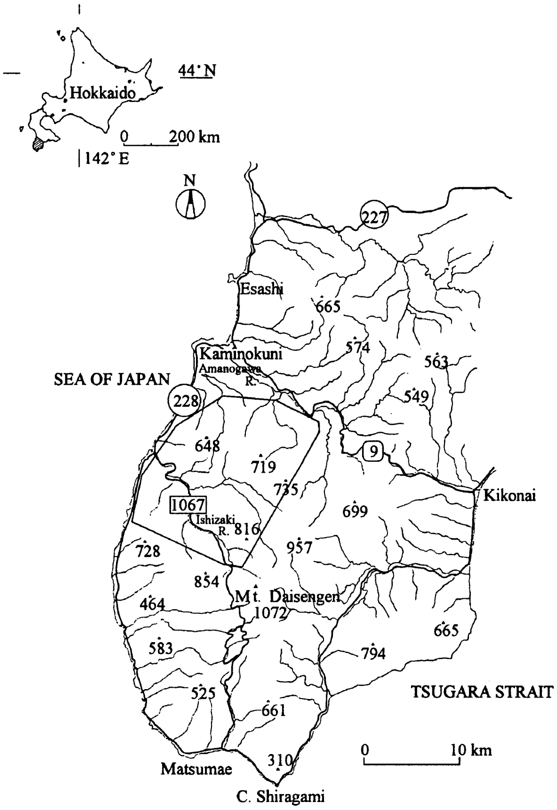

Fig. 1. Brown bear study area in southwestern Oshima Peninsula, Hokkaido. The polygon shows the outmost of the trap sites.

vegetation type is abbreviated as SBF. As the substantial forest of this vegetation type, beech and oak forest (BOF) is found in relatively lower areas. On the slope along the sea coast, maple and linden dominant forest mixed with oak is found. This vegetation type is abbreviated as MLF. The area near the ridge and higher than 600 m in altitude is occupied by birch (*Betula ermani*) stands with sasa bamboo under cover. This vegetation type is abbreviated as BF. The highest area over 800 m in altitude is a sasa bamboo community with *Sasa* spp. and alder (*Alnus crispa*). This vegetation type is abbreviated as SC. White pine (*Pinus pentafira* var. *himekomatu*) is found on the steep rock ridge. Along the riverside, forest of horse chestnut (*Aesculus turbinata*), wingnut (*Pterocarya rhorifolia*), elm (*Urmus laciniata*), and willow (*Salix* spp.) is found. Conifer plantation (CP) of fir (*Abies sacharinensis*), Japanese cedar (*Cryptomria japonica*), and larch (*Larix kaempheri*) is found in relatively lower areas. In the northern part of the study area, conifer forest of hiba (*Thujopsis dolabrata* var. *hondai*), is found regionally.

METHODS

Brown bears were captured in barrel traps baited with 1 kg honey (Mano et al. 1990), then immobilized with ketamine hydrochloride and xylazine hydrochloride (Tsubota et al. 1991), weighed, and measured. A lower fourth premolar tooth was extracted for age determination by counting cementum annual layers (Craighead et al. 1970). Every bear was equipped with 144 MHz radio collars (Lotek, Inc., Aurora, Ontario) and plastic ear tags. Radio locations of instrumented bears were made daily when possible by triangulation from the ground. I used a 3-element Yagi antenna and a FT290-mkII receiver (Yaesu Musen, Inc., Tokyo). Aerial radio locations (3 times by fixed-wing airplane and 2 times by helicopter) were made when bears were missed from the ground.

Bear locations were recorded on 1:50,000 scale topographical maps. The vegetation type of the radio locations was recorded by the same scale used in the Actual Vegetation Map (Japan Environment Agency 1984). Home-range size was calculated from the polygon defined by connecting the outermost radio locations (Mohr 1947). The expected frequency of radio locations by vegetation type when home range was used uniformly was calculated by multiplying the total number of the radio locations by the percentage of each vegetation type within the home range. Vegetation preference of bears was examined by comparing the expected and actual frequency. The mention of vegetation types was according to legend of the Actual Vegetation Maps of the Environmental Agency. Abbreviations of each vegetation type are shown in Table 1. I used *G*-test to determine significance in comparing.

RESULTS

In 12 captures between May 1987 and October 1988, 11 brown bears (7 M, 4 F) were captured and 10 bears (7 M, 3 F) were instrumented with radio collars. Only 1 female bear (No. 3) was monitored for 33 months in succession. Estimation of annual home range was available for this female bear in 1988 and 1989. As other individuals were continuously contacted from 4 days to 10 months, seasonal home ranges, but not annual ones, of those bears were estimated. The reasons for interruption of tracking were 2 losses of radio collars, 2 control kills, 2 troubles with radio transmitters, 1 poison kill, 1 unknown death, and 1 large movement. I obtained 687 radio locations for all bears. Habitat preference was examined for the bears No. 3, No. 6, No. 9, and No. 10. Radio locations of

Table 1. Abbreviation of vegetation types in the study area. Each name of vegetation type was according to legend of the Actual Vegetation Map of "KAMINOKUNI" and "DAISENGENDAKE" by the Japan Environment Agency (1984).

Vegetation type	Abbreviate name
Vegetation in Vaccinio-Piceetea (subarctic or subalpine) Region	
Sasa spp. community	Sasa community (SC)
Betula ermanii community	Birch forest (BF)
Sasa spp.-*Betula ermanii* community	
Natural vegetation in *Fagetea crenatae* (cold temperate) Region	
Saseto Kurilesae-Fagion crenae	Sasa-beech forest (SBF)
Acer mono var. *glabrum-Tilia japonica* community	Maple-linden forest (MLF)
Substitutional communities in *Fagetea crenatae* (cold temperate) Region	
Fagus crenata-Quercus mongolica var. *grosseserrata* community	Beech-oak forest (BOF)
Plant communities in clear-cut area	Clear-cut area (CCA)
Plantation	
Cryptomeria japonica, *Chamaecyparis obtusa*, *Chamaecyparis pisifera* plantation	Conifer plantation (CP)
Abies sachalinensis plantation	
Deciduous conifer plantation	
Cultural Land	
Field	
Weed communities in uncultivated field	Cultural land (CL)
Cultivated meadow	

No. 6 during 2-22 October 1988 were excluded for the analysis of habitat use because those were obtained on a garbage dump. A total of 464 radio locations was available for the analysis of habitat use.

Movements and Home Ranges

The continuous monitoring period, number of radio locations, and home range size of each bear are shown in Table 2. Generally, females showed smaller movement and were easier to track continuously than males. Female No. 3 was monitored throughout the study period. Female No. 9 moved within a small area in 1988 and 1989 (Fig. 2). Males moved extensively resulting in loss of signal. For example, subadult male No. 5 moved about 10 km within 12 hours. Moreover, the number of radio locations of adult male No. 11 from 9 April to 29 November in 1989 was only 19 (Table 2), although radio location was done throughout the period. Male No. 10, which dropped its radio collar during 10-20 November 1988, was killed by damage control on 6 September 1989 at a corn field 25 km from the dropped point, and this was the largest recognized movement of any bear.

Only the annual home-range size of female No. 3 in 1988 and 1989 was obtained. In this case, the movement of the bear was monitored from the day of den emergence to the day of den entrance. The size of annual home range was 39.1 km² and 28.1 km² for 1988 and 1989, respectively (Fig. 2). Although female No. 3 had been monitored only during late summer and autumn in 1987, the size of home range during this period was 56.2 km², which was nearly 2 times that of the annual home range in 1989 (Fig. 2). Seasonal home ranges were determined for bears No. 2 (1987 summer and autumn), No. 6 (1988 summer and autumn), No. 9 (1988 autumn, 1989 spring and summer), and No. 10 (1988 autumn)(Table 1). Location of each seasonal home range is shown in Fig. 3.

Habitat Use

Composition and proportion of vegetation type within home ranges, expected frequency according to the proportion, and the actual frequency of radio locations are shown in Table 3 to Table 8. The annual home range of female No. 3 was located in the interior part of the peninsula, which is occupied by the higher

Table 2. Successional monitoring period, number of radio locations and home-range size of each instrumented bear.

No.	Sex	Age	Year	Monitoring period	Season	No. of R.L.	Size (km²)
2	M	2	1987	11 Jul-14 Oct	summer-autumn	63	41.8
3	F	3	1987	12 Aug-26 Nov	summer-autumn	61	56.2
4	M	11	1987	26 Sep-27 Oct	autumn	20	37.9
5	M	2	1987	7 Oct-3 Jan	autumn	19	70.8
3	F	4	1988	22 Apr-8 Nov	annual	120	39.1
5	M	3	1988	2 Apr-28 Apr	spring	27[a]	64.5
6	M	12	1988	29 Jul-22 Oct	summer-autumn	44	40.9[b]
7	M	Adult	1988	17 Aug-21 Aug	-	4	-
8	F	8	1988	8 Sep-12 Sep	-	3	-
9	F	1	1988	18 Sep-10 Nov	autumn	40	7.6
10	M	1	1988	30 Sep-10 Nov	autumn	33	17.4
11	M	14+	1988	4 Oct-20 Nov	-	7	-
3	F	5	1989	10 Apr-13 Nov	annual	159	28.1
9	F	2	1989	3 Apr-21 Jul	spring-summer	68	6.7
11	M	15+	1989	9 Apr-29 Nov	-	19	-

[a] Plural radio locations were obtained within a day.
[b] Including a garbage dump which was used for 20 days.

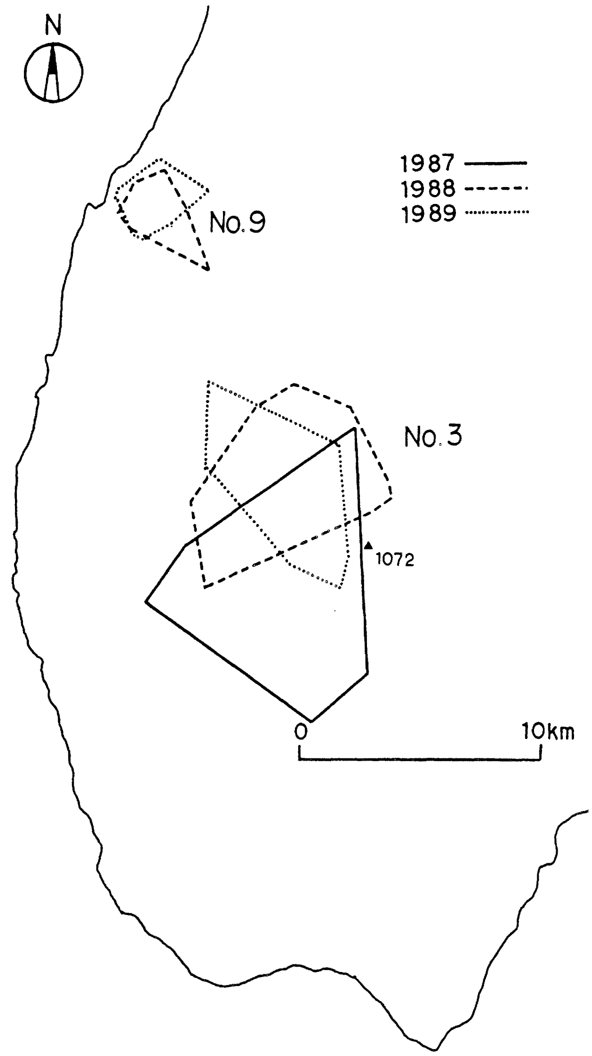

Fig. 2. Annual and seasonal home ranges of females No. 3 and No. 9. Monitoring periods of each home range are shown in Table 2.

mountains (Fig. 2). About 90% of this individual's home range was occupied by the SBF (beech forest) (Tables 3 and 4). There were significant differences between actual and expected frequency of vegetation types within home ranges in 1988 ($G = 13.73$, df = 3, $P < 0.01$) (Table 3). However, no differences were found in 1989 ($G = 2.45$, df = 3, $P = 0.48$) (Table 4). All 6 radio locations in BF were in mid or late June.

There were significant differences between actual and expected frequency in seasonal home ranges of No. 9 and No. 10 in 1988 and 1989 (Tables 6, 7, and 8). In 1988 autumn, No. 9 was more frequently found in the vegetation type MLF ($G = 45.59$, df = 3, $P < 0.01$) and No. 10 was found more in the vegetation type BOF ($G = 14.24$, df = 3, $P < 0.01$) than expected. On the other hand, both bears were found less in the vegetation type SBF than expected ($G = 21.41$, df = 3, $P < 0.01$), but there was no difference between the expected and actual frequencies of radio locations in the vegetation type of BF. In this case, the bear was found in BF from April to June. I found no differences between the expected and actual frequencies by vegetation types between the summer to autumn home

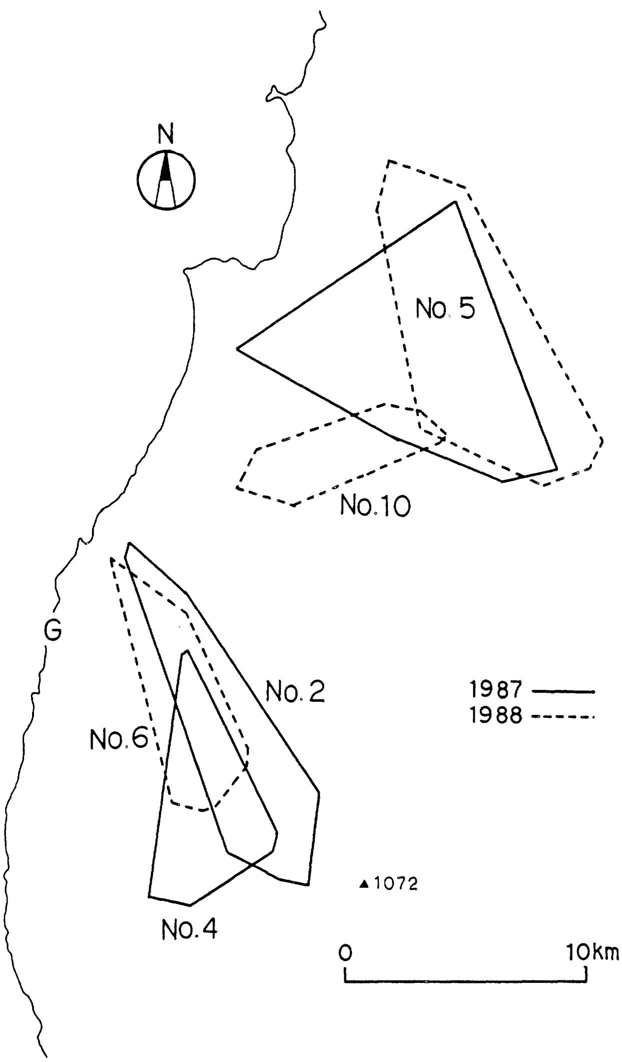

Fig. 3. Seasonal home ranges of males No. 2, No. 4, No. 5, No. 6, and No. 10. Monitoring periods of each home range are shown in Table 2. The mark "G" means a garbage dump to which male No. 6 was attracted during 2-22 Oct 1988 and killed.

range of No. 6 (G = 5.73, df = 3, P = 0.13) (Table 5).

DISCUSSION

Larger male movement and home-range sizes are general in most mammalian species (Greenwood 1980) and were present also in bears in previous studies (e.g., Jonkel and Cowan 1971, Pearson 1975, Craighead et al. 1976). Discontinuous radio locations of the male bears were caused by the unusually large movements

Table 3. Proportion of vegetation type within annual home range of female No. 3 in 1988 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Sasa community	9.4	11.3	3
Birch forest	2.6	3.1	1
Sasa-beech forest	86.7	104.0	113
Conifer plantation	1.3	1.6	4
Total	100.0	120.0	120

Table 4. Proportion of vegetation type within annual home range of female No. 3 in 1989 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Sasa community	2.6	4.1	3
Birch forest	0.5	0.8	0
Sasa-beech forest	93.6	149.0	149
Conifer plantation	3.3	4.3	7
Total	100.0	159.0	159

outside of the study area and males would have obviously larger home ranges than females although the size was not determined.

A majority of female No. 3's home range was composed of the vegetation type SBF. This vegetation type is found mostly in the interior part of the peninsula where the elevation is higher than 200 m. The lower frequency of use expected of SC and BF types in 1988 suggests that bears scarcely use subalpine areas such as SC and BF annually. No detected change in the 1989 habitat use could be because the proportion of SC and BF in the home range was too small to detect differences.

It is also suggested from the movement of female No. 3 that utilization of subalpine areas is restricted during late spring-early summer. Brown bears feed on succulent grasses and herbs such as skunk cabbage (*Symplocarpus foetidus* var. *lattimimus*), sedge (*Cares* spp.), angelica (*Angelica* spp.), and hogweed (*Heracleum dulce*), on the snowslide slopes or along the streams from spring to early summer (Abe et al. 1987, Kamada and Kuramoto unpubl. data). Female No. 3

Table 5. Proportion of vegetation type within summer-autumn home range of male No. 6 in 1988 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Sasa-beech forest	82.8	36.4	36
Maple-linden forest	0.9	0.4	1
Conifer plantation	11.4	5.0	7
Cultural land	0.6	0.2	0
Others	4.5	1.9	0
Total	100.0	44.0	44

Table 6. Proportion of vegetation type within autumn home range of female No. 9 in 1988 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Birch forest	11.5	4.6	1
Sasa-beech forest	54.9	22.0	5
Maple-linden forest	31.1	12.4	33
Conifer plantation	0.3	0.1	0
Cultural land	1.3	0.5	1
Others	0.9	0.3	0
Total	100.0	40.0	40

Table 7. Proportion of vegetation type within spring-summer home range of female No. 9 in 1989 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Birch forest	11.2	7.6	7
Sasa-beech forest	37.5	25.5	9
Maple-linden forest	46.8	31.8	48
Cultural land	3.0	2.1	2
Others	1.5	1.0	2
Total	100.0	68.0	68

Table 8. Proportion of vegetation type within autumn home range of male No. 10 in 1988 and a comparison between the expected frequency and the actual frequency of radio locations.

Vegetation type	Proportion (%)	Expected frequency	Actual frequency
Sasa-beech forest	63.8	21.1	13
Beech-oak forest	10.5	3.5	10
Clear-cut area	1.0	0.3	1
Conifer plantation	17.1	5.6	9
Cultural land	0.7	0.2	0
Others	6.9	2.3	0
Total	100.0	33.0	33

would feed on these grasses and herbs growing near the last remaining snow in subalpine areas during June. Seasonally restricted utilization of subalpine areas was also suggested by the habitat use of female No. 9. Although there was no difference between observed and expected frequencies in the vegetation type BF in spring, it was observed less then expected in autumn. Seasonally earlier observation of female No. 9 than No. 3 in the subalpine area could be caused from the earlier snow melt and plant chronology.

Bears having their home ranges in lower elevation areas, such as female No. 9, intensively used the vegetation type MLF within seasonal home ranges in the spring and autumn. Male No. 10 also used BOF intensively in the autumn. In the study area, the vegetation type MLF is found on the slope along the coast. Moreover, the vegetation type BOF, which is constituted by the secondary stand of beech forest, is found near farmland or residential areas. Both vegetation types are composed of stands of deciduous trees and vines. Acorn and berries are the most important autumn food of brown bears in deciduous and mixed forest of Hokkaido (Aoi 1985, Abe et al. 1987, Kamada and Kuramoto unpubl. data). Intensive use of these vegetation types likely is due to the abundant food in these vegetation types.

I could not recognize habitat preferences by vegetation types in the summer home range of male No. 6. In summer, brown bears in Hokkaido forage succulent herbs and insects, mainly ants and bees (Aoi 1985, Abe et al. 1987, Kamada and Kuramoto unpubl. data) and their foods are different than in autumn. This could be the reason that distribution and abundance of summer food items was not influenced by the vegetation type as much as spring or autumn items. Thus, spatial and temporal changes of food availability could influence the habitat selection of the bears.

Cold, temperate forest areas, such as beech forest and deciduous forest in lower areas, were intensively used and were more important for brown bears than the subalpine areas such as birch forest and sasa community. Lower deciduous forest areas such as beech-oak forest and maple-linden forest would be most important for brown bears with home ranges in lower areas or the large moving males who use such areas.

Thus, in the study area, the border of human residential areas and important bear habitat is likely to overlap. This means simply establishing a bear conservation area by zoning will be difficult. The beech forest and maple-linden forest proved to be most important. Maintenance of the beech forest area as bear habitat is essential to reduce human encounters near the residential area. Unfortunately, in present Japanese Government forest policy, the principle ideas of wildlife habitat management are still in the development stage. It will be necessary to reduce sources such as garbage that attract bears to residential areas (Mano 1990), and will also be necessary to consider bear habitat maintenance and restoration in forest policy in the immediate future.

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