Wildlife Conservation in Forested Landscape in the Ota River Watershed, Hiroshima

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Abstract

In Japan, wildlife particularly in watershed area is threatened by extensive impact of human activities. As a result wildlife intruded into human settlement as well as agricultural land, which caused conflict between human and wildlife. To overcome the conflict, effective mitigation to ensure the sustainability of a particular area is necessary. Nevertheless, the relationship between wildlife disturbances and changes in land use must be understood. Thus, the objective of this study is to present the current status and trends of wildlife disturbance and changes in land use as Ota River watershed of Hiroshima Prefecture, Japan as a case study. Results revealed that wild boar was the most disturbance species represented about 73% of total disturbance in the period between 1981 and 2002. Generally, in other species such as sika deer and Japanese monkey, the percent of disturbance was not much changed over the period. Landscape pattern analysis showed that fragmentation (measured by number of patches and mean patch size metrics) increased in the watershed between 1994 and 2000. However, heterogeneity (measured by Shannon's diversity index) of the watershed was almost the same in the two temporal years. Correlation analysis revealed that changes in wild boar disturbance were significantly influenced by changes in forest area ($p<0.01$). Analysis in 15 town/wards in Ota River watershed showed that by 2000 forest was the major land use except in Nishi-ku, Fuchu-cho, Naka-ku and Minami-ku. In conclusion, fragmentation of the Ota River watershed was an important factor affecting wildlife disturbance especially wild boar. To minimize and control the disturbance, maintenance of existing natural habitats is vital for conserving the watershed biodiversity and ecosystems.

Key Words: wildlife disturbance, forest landscape, Ota River Watershed

1. Introduction

Wildlife conservation is one of the important environmental issues that have been discussed in many countries around the world. Destruction of forested areas due to various human land use activities remain as the main factor contributed to the scenario. Forest loss and fragmentation can have broad ecological effects such as loss of wildlife habitat, declining in population, ecological interactions and biodiversity (Fahrig & Grez 1996, Grez *et al*. 1998, Turner *et al*. 2001). In small or fragmented patches populations tend to be more vulnerable to extinction (Gilpin 1987, Goodman 1987).

Japan is not exceptional from this issue. The country considerably has high diversity of wildlife compared to the other country within the same geographic or climatic zone **(Table 1)**. However, clear-cut logging, road construction, motorized vehicle trails, and encroaching urbanization are taking a toll particularly in remotely watershed forest landscape. One of the major consequences is a conflict between human and wildlife in agricultural land and human settlement.

According to report by Wildlife Conservation and Management in Japan (1996), damage to agricultural land and human settlement by wildlife particularly by wild boar (*Sus scrofa*), sika deer (*Cervus nippon*) and monkey (*Macaca fuscata*) has been increased particularly since 1975. This trend has been increased extensively and caused decline in agricultural productivity and resulting land abandonment. Crop damage by deer and wild boar has been an on-going struggle for farmers. Some measures, for example, capture and control of harmful mammals has been implemented, however the problem is still occurred indicated by increased in damage of agriculture land. To address this situation, effective measure to ensure the coexistence between conservation of wildlife and agriculture and forestry communities is necessary. However, information regarding the status of wildlife, their disturbance and its relationship to changes in land use must be developed. Therefore, the purpose of this study is to present the current status and trends of wildlife disturbance and changes in land use of forested landscape.

Table 1. Wildlife in Japan.

Taxanomy group	Number of species
Mammal	188
Bird	665
Reptile	87
Amphibian	59
Freshwater fishe	200
Insect	28,720
Arthropod	192
Inland/freshwater shellfish	824
Other invertebrate	44,040
Vascular plant	8,118
Seaweed	1,850
Moss	2,295
Lichen	2,295
Fungus	10,000

2. Study area

The case study area is Ota River watershed, located in the western Hiroshima Prefecture. The total area of this watershed is 1,700 km^2 **(Figure 1)**. This watershed is very important because it drains a single body of water such as stream, lake, wetland, or estuary of western part of Hiroshima Prefecture. According to Nakagoshi *et al*. (2004), human activities such as logging and land development have become a critical issue in this watershed where the main river, the Ota River flows into the sea of Seto Inlands.

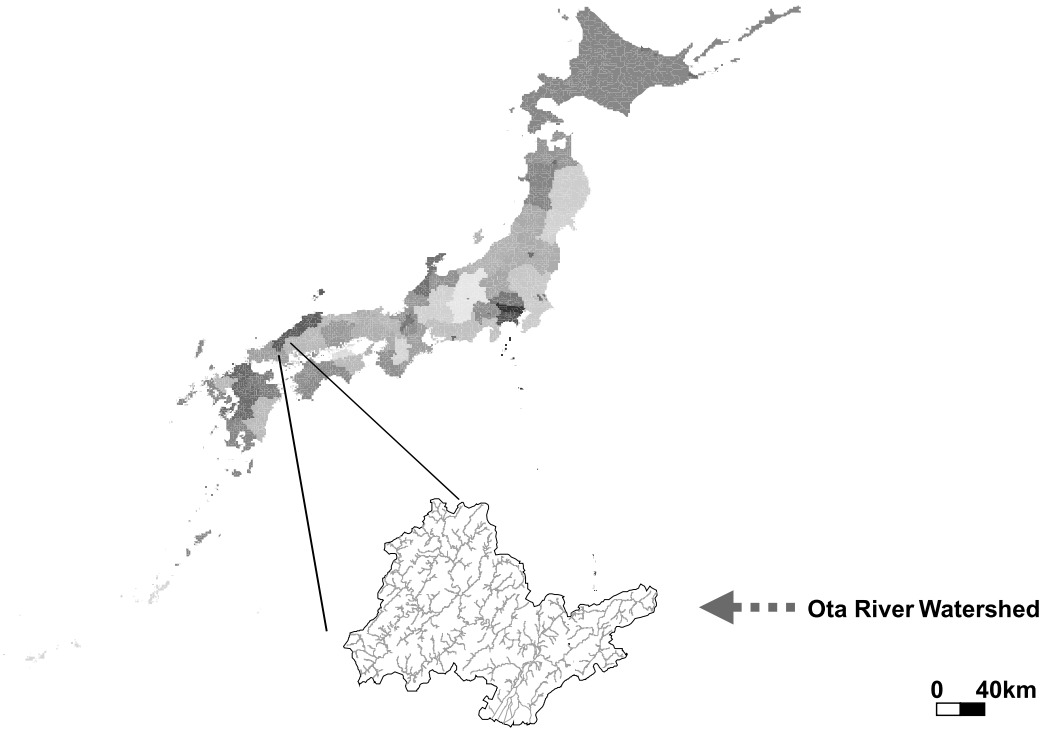

Figure 1. Location of the Ota River watershed.

3. Methods

3.1 Data acquisition and analysis

There are two sets of data in this study; wildlife disturbance and digital land use maps. Data of wildlife disturbance from 1981 to 2002 were obtained from government prefecture of Hiroshima (Anonymous 2004). The digital land use maps (scale 1:25,000) of Ota River watershed from two different temporal years, 1994 and 2000 were obtained from the Environment Agency's of Japan. Both maps were transformed into the same geo-reference – WGS 1984 UTM Zone 53N by using geographic information systems (GIS) application of Arc Map 8.2. In this study seven land use types were developed

Table 2. Description of landscape metrics used to calculate landscape structure of Ota River watershed (McGarigal & Marks 1995).

Landscape metric	Calculation	Unit	Range
Mean patch size	MPS＝A/N*(1/10000)	Hectares	MPS>0, without limit
Number of patches	NP＝N	None	NP≥1, without limit
Shannon's diversity index	$-\sum (P_i * \ln P_i)$	None	SHDI≥0, without limit

*N＝Total number of patches in the landscape
A＝Total landscape area (m^2)
P_i＝Proportion of the landscape occupied by patch type (class) i

based on classification made by Naturalness: Japan Environment Agency. The seven land use types are as follows: 1. Forest; 2. Paddy field; 3. Grassland; 4. Plantation; 5. Urban and built-up area; 6 Water and 7. Others.

Landscape pattern analysis was performed using Patch Analyst 3.2 (Elkie *et al*. 1999). Analysis was conducted at two levels; landscape level (comprising all types of land use) and class level (each type of land use). In these analyses three landscape metrics (O'Neill *et al*. 1988, Turner 1990, McGarigal and Marks 1995) were chosen to present the landscape structure of the watershed in 1994 and 2000. The selected metrics and its definition are presented in **Table 2**. Correlation analysis was conducted to present the relationship between the percentage of wild boar change and the percentage of land use change from 1994 to 2000. Land use analysis was also conducted in each town/ward that fall within the Ota River watershed. The towns/wards are as follow: 1. Geihoku-cho; 2. Toyohira-cho; 3. Togochi-cho; 4. Kake-cho; 5. Mukaihara-cho; 6. Asakita-ku; 7. Yoshiwa-son; 8. Tsusuga-son; 9. Yuki-cho; 10. Asaminami-ku; 11. Higashi-ku; 12. Nishi-ku; 13. Fuchu-cho; 14. Naka-ku; 15. Minamu-ku.

4. Results

4.1 Land use pattern

Results revealed that forest was the major land use in Ota River watershed both in 1994 and 2000. However, the proportion of forest was slightly decreased in 2000 (54.8%) compared to 1994 (55.5%). Grassland was the second major land use in the watershed in 1994 and 2000. However, its proportion increased from 16.7% in 1994 to 17.3% in year 2000. A similar pattern was shown by urban and built-up area (1994-3.1%; 2000-5.6%). The proportion of paddy field (1994-12.9%; 2000-10.4%) decreased over the years whereas the proportion of plantation and others were almost the same.

In 1994, forest was the major land use in all towns/wards except Nishi-ku, Naka-ku and Minami-ku **(Table 3)**. In these towns/wards urban and built up area was the main land use type. A similar pattern was shown in 2000 except Fucho-cho where urban and built-up area emerged as the main land use type **(Table 4)**.

4.2 Landscape structure

In general, the number of patches increased from 1994 to 2000. The reversed pattern was shown by mean patch size (MPS), which decreased from 27.28 ha to 26.24 ha **(Figure 2)**. Shannon's diversity index was almost the same in 1994 and 2000 **(Figure 3)**.

Table 3. Percentage of land use types by town/wards in Ota River watershed in 1994.

Town/wards	Forest	Paddy field	Grassland	Plantation	Urban and built up area	water	Others
Geihoku-cho	64.23	8.57	18.99	7.59	0.03	0.59	0.01
Toyohira-cho	62.73	17.53	14.06	5.33	0.27	0.07	0.00
Togochi-cho	53.64	4.09	28.36	12.73	0.38	0.70	0.10
Kake-cho	52.15	9.63	15.24	21.23	0.34	1.41	0.00
Mukaihara-cho	70.67	15.50	10.34	2.60	0.26	0.36	0.28
Asakita-ku	62.07	17.48	11.35	6.05	2.08	0.96	0.00
Yoshiwa-son	57.28	2.89	22.13	17.30	0.02	0.39	0.00
Tsutsuga-son	37.07	7.97	28.15	25.98	0.34	0.50	0.00
Yuki-cho	42.60	5.02	20.10	30.36	1.20	0.73	0.00
Asaminami-ku	50.06	27.13	14.34	5.85	2.17	0.44	0.00
Higashi-ku	51.72	33.68	8.85	1.01	3.24	1.51	0.00
Nishi-ku	32.11	13.74	9.21	0.00	36.89	7.08	0.97
Fuchu-cho	40.60	23.45	6.92	0.39	27.63	1.00	0.00
Naka-ku	0.00	0.00	0.00	0.00	80.52	19.48	0.00
Minami-ku	9.11	19.76	0.63	0.00	58.79	11.40	0.31

Table 4. Percentage of land use types by town/wards in Ota River watershed in 2000.

Town/wards	Forest	Paddy field	Grassland	Plantation	Urban and built up area	Water	Others
Geihoku-cho	63.47	8.10	20.67	6.95	0.03	0.77	0.01
Toyohira-cho	62.22	18.14	14.21	5.03	0.28	0.11	0.00
Togochi-cho	52.16	4.41	28.88	13.27	0.41	0.77	0.10
Kake-cho	51.18	10.43	14.92	21.47	0.33	1.68	0.00
Mukaihara-cho	70.29	14.73	11.96	1.98	0.25	0.50	0.29
Asakita-ku	62.51	14.89	11.28	5.90	4.51	0.91	0.00
Yoshiwa-son	56.81	2.27	23.72	16.74	0.02	0.46	0.00
Tsutsuga-son	35.64	6.98	28.57	27.98	0.33	0.50	0.00
Yuki-cho	42.73	5.41	20.01	30.54	0.49	0.82	0.00
Asaminami-ku	49.23	17.12	14.96	5.17	12.65	0.87	0.00
Higashi-ku	49.28	9.50	10.06	1.47	28.99	0.70	0.00
Nishi-ku	25.33	5.85	7.23	0.00	51.31	9.31	0.97
Fuchu-cho	40.62	1.82	4.71	0.37	52.05	0.43	0.00
Naka-ku	0.00	0.00	0.00	0.00	78.29	21.71	0.00
Minami-ku	9.86	0.99	0.78	0.00	80.11	7.99	0.26

4.3 Wildlife disturbance

Result showed that from 1981 to 2002 a total of 6 species; wild boar, sika deer, monkey, wild dog, rabbit and black bear were identified as disturbance species **(Figure 4)**. Among these, wild boar emerged as the major disturbance species, which represents about 73% of total number of wildlife dis-

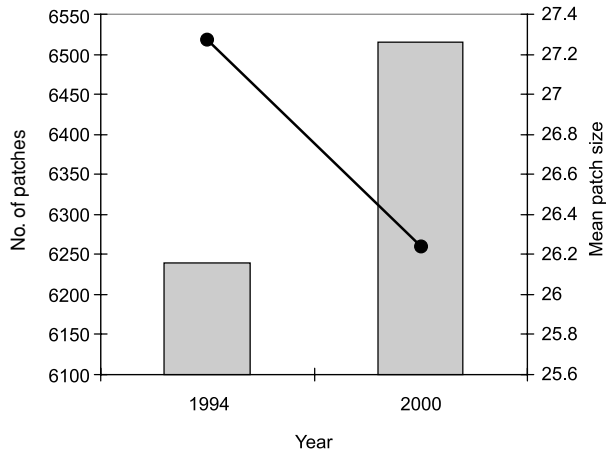

Figure 2. Number of patches (bar) and mean patch size (line) of Ota River watershed in the two temporal years.

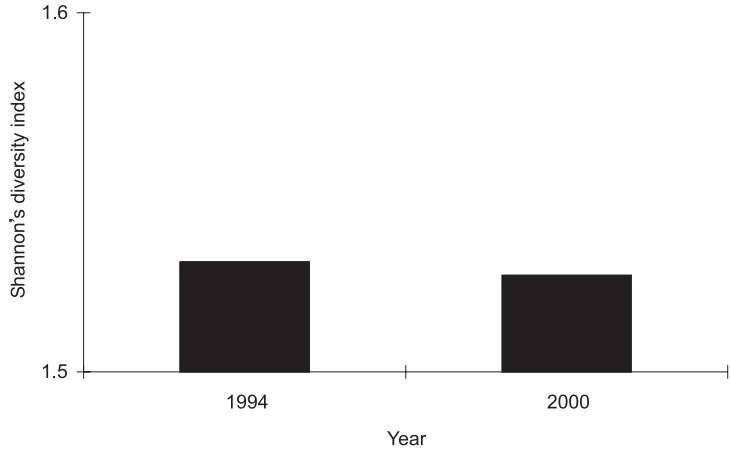

Figure 3. Shannon's diversity index of Ota River watershed in the two temporal years.

turbance. This followed by sika deer (14%) and monkey (7%). Correlation analysis revealed that changes of wild boar disturbance were significantly influenced by changes in forest area ($p<0.01$) **(Table 5)**.

Over the years the disturbance by wild boar increased gradually **(Figure 5)** but the pattern was not much changes showed by other species except sika deer, which slightly increased from 1996. Almost all town/wards in the watershed experienced disturbance by the animal species except Naka-ku and Minami-ku. The number of wild boar disturbance mainly occurred in Asakita-ku and Asaminami-ku.

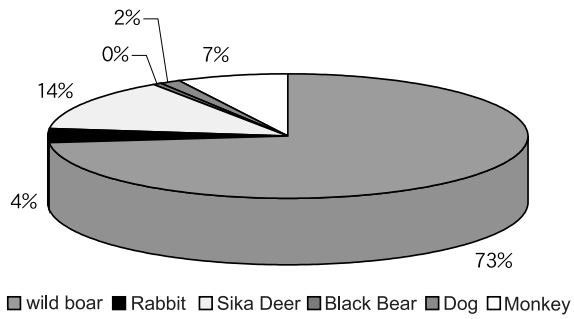

Figure 4. Proportion of disturbances by wildlife in Ota River watershed from 1981 to 2002.

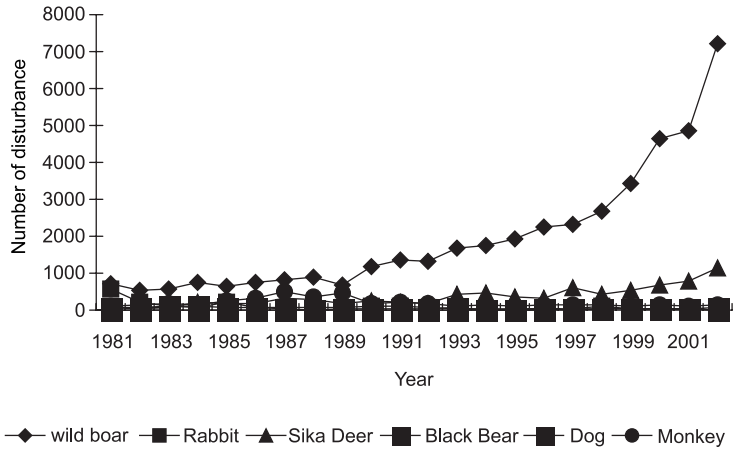

Figure 5. Number of disturbance by wildlife in Ota River watershed from 1981 to 2002.

Table 5. Correlations between wild boar percentage change and change of percentage of each land use class level.

	Forest change	Paddy field change	Grassland change	Plantation change	Urban and built up area change	Water change	Others change
Wild boar change	0.738**	−0.032	−0.178	−0.120	0.297	−0.229	−0.474

**p<0.01

5. Discussion

The increased in number of patches and decreased in mean patch size revealed that fragmentation process occurred in Ota River watershed. Increase in landscape fragmentation suggests that the water-

shed experienced highly development of human activities. As shown in this study the main impact was declining in size of forested area particularly the natural forest. The size of forest patches is the most important to ensure the conservation of wildlife (Turner *et al*. 2001). Ecologically, patch with large size usually inhabits more species and population than smaller patches (Opdam 1991). Furthermore, larger patches have more environmental variability such as differences in microclimate, structural variation in plants, and diversity of topographic position (Wilcove *et al*. 1986). These variables provide more opportunities for organisms with different requirement and tolerances to find suitable sites within the patch. In addition, edges and interiors of patches may have different conditions that favour some species but not others (Williams-Linera 1990). The relative abundance of edge versus interior habitats varies with patch size. Smaller patches have a greater perimeter-to-area ratio than larger patches, which means that smaller patches will have a greater proportion of edge habitat and the larger patch will have a greater proportion of interior habitat (Kareiva 1987, Hanski & Gilpin 1997).

In Japan, deforestation mainly occurred in the 1960s but by the 1990s it gradually decreased. Industrialization and urbanization exhibited by various land use change, such as building constructions on farmlands, reclamation and afforestation. In the post-war years, Japan underwent rapid industrialization and urbanization occurs heavily in many cities resulting decreased in proportion of green space (Nakamura 1998). Other ecosystems such as streams, lakes, and ponds were noticeably polluted (Mitsudera *et al*. 1977, Adams 1994). Eventually, all these might affects the habitat quality of wildlife.

In Ota River watershed, however, fragmentation of forested areas has caused conflict between wildlife and human particularly the disturbance by wild boar. However, in general the consistent pattern of disturbance by other species suggests that the reforestation activity by government of Hiroshima Prefecture was likely to prevent increase in disturbance of several species. Nevertheless, conserving natural forest area is better than reforestation because some of wildlife species are disable to adapt to the new habitat. The clear case in this study was probably wild boar given that their disturbance increased over the period. Species that are unable to adapt in altered habitats are being forced into small and marginal habitat patches. However, in the case of wild boar, this species has flexibility to adapt to the changing ecology and disturbed area such as agricultural land and often come into direct competition with human and are persecuted as pets.

Generally, conservation of wildlife in the watershed requires a management plan that forest can provides and supply food resources for wildlife. The first step in developing such plan is to determine which vegetation type is mainly utilize or inhabit and provide food resources for wildlife. However, in making decisions about land-use management and resolving human-wildlife conflicts from national perspective, compromises must be made between different interest groups and different levels of society, e.g. national, community and individuals (Siex & Struhsaker 1999).

In conclusion to minimize wildlife disturbance, maintenance of existing natural habitats is vital for conserving the watershed biodiversity and ecosystems. Restoration works are also great important. Thus, an approach that combines both these processes is necessary. To begin with, the extent of damage and the current direction and process of change at each site must be clearly documented. Next, the goals of maintenance or restoration, in terms of the final form of the desired natural environment, must be established. Destructive development and intensive agricultural development must be minimizing, required in many areas within watershed. Riparian habitat along many rivers and irrigation canals is also needed to include in restoration programme to support greater biodiversity and to reduced conflict between human and wildlife.

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