

The Influence of Forest Resource Use on Forest Landscapes in the Abukuma Mountainous Area in the Past 90 Years

Asako Miyamoto, Makoto Sano

Forestry and Forest Products Research Institute

Introduction

Understanding historical backgrounds can provide valuable insight into current ecosystems and biodiversity (Foster1992). Recent studies have further demonstrated that past land use and landscape changes significantly affect biodiversity (Courins and Eriksson 2002; Gachet et al. 2007).

Many studies have been conducted in Ogawa Forest Reserve, a remnant old-growth *Fagus crenata* forest in the southern part of the Abukuma mountains in Japan (Nakashizuka and Matsumoto 2002). It has been reported that the forest has been much affected by large-scale disturbances due to past land use (Suzuki 2002), but there is still a lack of detailed information concerning land use and landscape history in this region. Integration of comprehensive information on land use with the landscape history of the area surrounding the remnant old-growth forest could provide practical and useful information for planning the optimum conservation and management of this forested area as well as provide deep insights into the current biodiversity there.

The purposes of this study are 1) to clarify the socioeconomic forces which brought about changes in forest landscape around Ogawa Forest Reserve in the southern Abukuma mountains, utilizing literature surveys and interviews with local residents, and 2) to reconstruct past forest landscapes and quantify the landscape changes that have occurred from the beginning of the 20th century to the present, using old topographic maps and aerial photographs.

Methods

Study site

The study area covers about 10,000 ha of the Abukuma mountainous area in the Ibaraki and Fukushima prefectures of central Japan (Fig.1). The mean annual temperature is approximately 10.7°C and the mean annual precipitation is 1,910 mm (Mizoguchi et al., 2002). Hilly areas ranging from 600–700 m a. s. l. dominate a large part of the study area, and these have allowed horse production to prosper in the past. The forests have been subjected to substantial influence from human activity such as horse grazing, clearcutting for charcoal and fuelwood, and burning to maintain grasslands (Suzuki 2002). Most of the forest is now secondary forest or coniferous plantations, and only a few areas of old-growth forest remain. Ogawa Forest Reserve (OFR) was established in the national forest area in 1969 to preserve one of such rare old-growth, temperate, deciduous forests composed of *Fagus crenata*, *F. japonica* *Quercus mongolica* var. *crispula* and *Carpinus spp.* Forest covered approximately 8,800ha of the study area, and 77% of that is national forest. The area of private forest is minor, and most of the lands owned by private landowners are small in size.

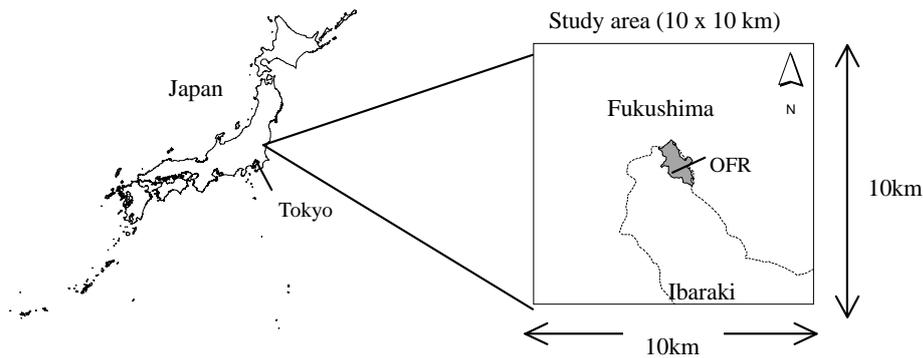


Fig.1 Location of study area. The study area covers about 10,000ha of the southern Abukuma mountainous area. It incorporates the 100 ha Ogawa Forest Reserve(OFR).

Interview and literature survey about forest resource use

We conducted interviews with local residents to clarify the socioeconomic forces which caused changes in land use. In the interviews, we inquired about the changes in forest types and forest resource uses, and also about their causes. Since we focused particularly on the changes around OFR, we conducted interviews with local residents of the Sadanami and Ogawa areas of Kitaibaraki city, Ibaraki prefecture where OFR is located. Interviews were conducted with elderly people in the village, such as the village headman, people who had worked at the local forestry office, and people who knew the history of village well. Since it was difficult to interview a large number of people and to obtain precise information on detailed conditions dating as far back as 90 years ago from interviews alone, we also referenced literature about local history and national forest management plans.

Reconstruction of past land uses

We identified the major turning points of the forest resource use from the interviews, and prepared multiple land use maps corresponding to them to understand landscape transitions. Data on past forest landscapes was obtained from old topographic maps at a scale of 1:50,000 published by the Geographical Survey Institute in 1908. In addition, we used aerial photographs at four time points: (1) the earliest available black and white aerial photographs, at a scale of 1:40,000, taken by the U.S. military in 1947; (2) black and white aerial photographs at a scale of 1:16,000 taken by Japan's Forest Agency in 1962; (3) color aerial photographs at scale of 1:10,000 taken by Japan's Geographical Survey Institute in 1975; and (4) the most recent black and white aerial photographs, available at scale of 1:16,000, taken by Japan's Forest Agency in 1997. The land use patterns were classified into four categories: grasslands, deciduous broad-leaved forests (deciduous forests), coniferous plantations, and other land uses. Grasslands include pastures, meadows, and cutover lands. Deciduous forests are dominated by *Quercus serrata*, *Q. crispula*, *Castanea crenata*, *Carpinus laxiflora*, and *Carpinus tschonoskii*. Coniferous plantations include *Cryptomeria japonica* and *Chamaecyparis obtusa*. Other land uses include agricultural fields, villages, and public facilities. All land use maps were prepared as vector maps using GIS software TNTmips Ver. 6.8 (MicroImages Inc.). The

areas of each land use were calculated to determine the quantitative changes of the land use.

Results

Changes in forest resource uses

Based on the literature survey and the interviews, the pattern of forest resource uses was divided into three periods: (1) the period from pre-war to the post-war reconstruction period, characterized by multi-use of timber and non-timber forest products such as producing fuelwood and charcoal, pasturing and mowing, and collecting fertilizer for agricultural fields, (2) the economic growth period, characterized by the start of a decrease in most uses of forest resources and by the promotion of conifer planting, and (3) the stable growth period, characterized by the decline of forest resource use (Fig.2).

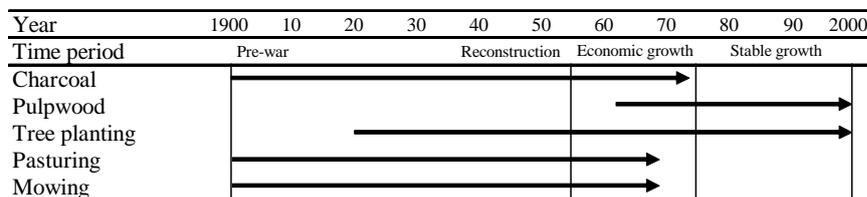


Fig.2 Changes in forest resource uses

Pre-war to reconstruction period (1900s to the first half of the 1950s)

The major industries of this period were charcoal production and horse production. Charcoal production was a side job for most farmers. Generally, they produced charcoal only in the farmers' off-season, although some of them produced it throughout the year. Charcoal producers built rough lodges in the forest and moved there in the winter season for charcoal production (Hanawa-machi 1986). In this region, private forest accounted for only 23% of the forest area and most of the private forests were small. Therefore, the role of the national forest was important for forest resource uses. The local forestry office established custodial forest for the purpose of mowing for agriculture or for charcoal production, and made it available to the neighboring villages (Tokyo Regional Forest Office 1925). Horse production was one of the main industries. At that time, villagers accessed both national and private forests freely to use them as pasture and mowing sites. However, after the demarcation between the national and the private forest ownership, it became difficult for the villagers to use national forest freely for pasture and mowing (Hanawa-machi 1986).

Economic growth period (the latter half of the 1950s to the first half of the 1970s)

After the war, the traditional wood consumption patterns changed. Demand for pulpwood and construction timber increased with the growth of the Japanese economy, whereas fuelwood and charcoal production gradually decreased due to the energy revolution. Government promoted expansive afforestation with conifer plantations, which led to deciduous forests being cut down and converted to conifer production. Villagers were engaged in labor for site preparation, tree planting, and brushing in the national forest (Forest Agency 1964). Villagers used to collect grass, fallen leaves and twigs in common lands and forests. As tree planting in the grasslands gradually accelerated, the amount of available grass decreased. Up to the first half

of the 1960s, horse production was converted to cattle production and utilization of grassland as pasture and mowing sites continued to decrease (Society of Sociology of Law of Ibaraki University 1956).

Stable growth period (after the first half of the 1970s)

During this period, the area of tree planting kept on decreasing. Forest resource uses in villages were continuously decreasing due to the decline of plantation activity in the national forest, and due to depopulation and aging of villagers.

Changes in land uses

Pre-war to reconstruction period (1900s to the first half of the 1950s)

Before this period (in 1908), the area was dominated by deciduous forest (70.5%) and grassland (27.3%), while there was no significant coniferous plantation in the study area (Fig.3, Table 1). Because the main industries were charcoal production and horse production, grasslands were utilized frequently as pasture and mowing, and the majority of grasslands were located close to the village (Fig.3).

Grassland decreased to 20.2% in 1947, and the majority of the decrease was replaced by deciduous forest and coniferous plantation during this period (Fig.3). Coniferous plantation emerged as a landscape element and accounted for 18.1% of the total area (Table 1).

Table 1 Changes in proportion of land use from 1908 to 1997

	1908	1947	1962	1975	1997
Coniferous plantation	0	18.1	28.1	46.2	48.4
Broad-leaved forest	70.5	64.0	58.6	35.9	32.9
Grassland	27.3	7.1	1.9	6.3	3.7
Others	2.3	10.8	11.4	11.5	15.1

Economic growth period (the latter half of the 1950s to the first half of the 1970s)

During this period, grassland decreased to 1.9% by 1962 before increasing again to 6.3% in 1975 (Table 1). In this same period, deciduous forest decreased from 58.6% in 1962 to 35.9% in 1975 (Table1). In contrast, coniferous plantation increased gradually, and it occupied approximately half of the study area (46.2%) in 1975 (Table 1). Coniferous plantation replaced deciduous forest, and became the most abundant landscape element in the study area.

Stable growth period (after the first half of the 1970s)

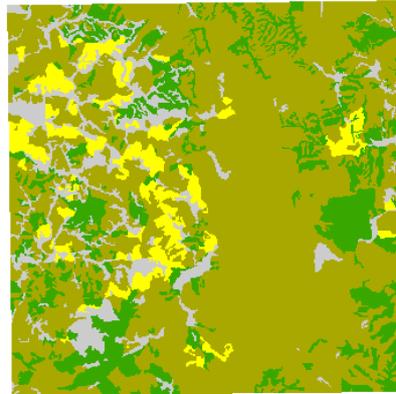
The areas of deciduous forest and coniferous plantation remained largely stable relative to the areas in 1975 (Table 1). However, many small narrow patches of deciduous forest appeared in the coniferous plantations (Fig.3).

Prewar-Reconstruction period

1908

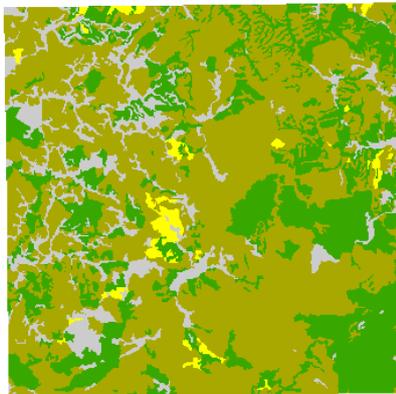


1947

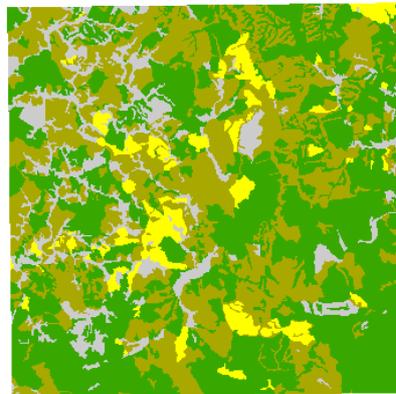


Economic growth period

1962



1975



Stable growth period

1997

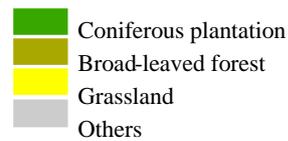
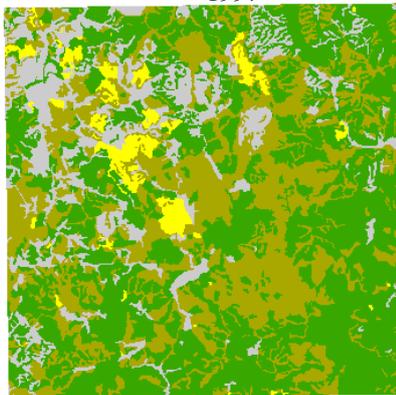


Fig.3 Land use change from 1908 to 1997

Discussion

The pattern of forest resource use changed drastically over the 20th Century, with the history of resource use being divisible into three periods (Fig.2) that paralleled the stage of economic growth. The landscape also

changed along with these changes in forest resource uses. Before the war a lot of grasslands remained in the study area. However, most of the grasslands were replaced by deciduous forests or coniferous plantations. These changes seem to be caused by the prohibition of burning in national forests in 1929, the cessation of management of mowing sites due to labor shortages during the war, and the planting of conifer trees in grasslands (Tokyo Regional Forest Office 1947). In the economic growth period, the Forest Agency promoted expansive afforestation to supply the increasing demand for wood and to meet changes in fuel demand. The changes in the landscape of the study area clearly reflected these changes. Furthermore, the decrease of grassland in 1962 may have been caused by the introduction of chemical fertilizer instead of grass mowing, the growth in demand for beef, and the decline in the use of horses due to improvements in agricultural machinery and changes in the industrial structure. As a result of these driving forces, the use of grasslands as mowing sites and pasture declined drastically. In 1975, the area of grasslands increased a little (Table 1). In those days, the grasslands were abandoned, although parts of them remained, being improved from semi-natural grasslands to artificial grasslands for cattle, and new artificial grasslands were established. These grasslands and cut-over lands were included in the grasslands category of 1975, and the usage and the content of grasslands were completely different from the previous period. In the stable period, the total area of secondary forest patches remained almost stable from 1975 to 1997 (Fig.4), but many small, narrow secondary forest patches emerged in coniferous plantations (Fig.3). While logging proceeded in secondary forests, some plantation areas were abandoned due to labor shortages and an aging farming population, and those areas were replaced by secondary forests. Narrow patches must also have been kept as buffer strips to protect cut-over land and preserve scenic beauty under the “New forest management in the national forest” in 1973.

In the study area, many deciduous forests and grasslands had been kept for long periods of time because deciduous forest was an important resource for producing charcoal (coppiced every 20-30 years), and grassland was needed as mowing sites and pastures. However, the deciduous forests and the grasslands became fragmented or disappeared with the changes in forest resource uses. As a result, the landscape has drastically changed. Such modification and the loss of landscape elements mean the modification and loss of natural habitat for wildlife. In coppice forest of the Kanto district, clear relationships have been found between fragmentation of woodlands and the decrease of rare species and forest floor plants (Iida and Nakashizuka 1995). Loss of biota and biodiversity is feared as a result of stopping the cyclic use of forest resources in rural areas (Okubo et al. 2000; Kamihogi 2002). Maintaining or reconstructing suitable forest environments may be effective methods for preserving flora and fauna maintained in relation to traditional land use. However, this would require an enormous expenditure of effort and time. Therefore, as suggested by Inoue (2003), consideration should be given to effective methods to create an alternative environment through variations on current forest operation, such as rotated logging operation, which provides alternative habitats for wildlife as a substitute for those provided by traditional forest operation (coppicing) and grass mowing.

In this study, we were able to show the close relationships between the changes in society and human activities and forest landscape. Quantification of the land use and landscape history may contribute to the development of biodiversity research in fields such as biodiversity change at the regional scale, the

contribution of landscape structure to regional biodiversity, the influence of fragmentation on biodiversity, and the prediction of future biodiversity in association with change of land use.

Acknowledgments This research was partly supported by the Research Institute for Humanity and Nature of Japan's Ministry of Education, Culture, Sports, Science and Technology (Project P2-2). We thank the Samegawa town office and the Tabito branch office of Iwaki city hall, and the people of Ogawa for offering their useful information. We also thank Mr. Yamagata Hajime for supporting the interview survey.

References

- Coursins SAO, Eriksson O (2002) The influence of management history and habitat on plant species richness in a rural hemiboreal landscape, Sweden. *Landscape Ecol* 17: 517-529
- Forest Agency (1964) Ringyo roudou no syugyou keitai ni kansuru jittai tyosa-Fukushima ken Iwaki gun Tabito mura oyobi Kawamae mura- (Investigation of actual condition concerning forest labor-Tabito village and Kawamae village, Iwaki county, Fukusima prefecture) (in Japanese)
- Foster DR (1992) Land-use history (19730-1990) and vegetation dynamics in central New England, USA. *J Ecol* 80: 753-772
- Gachet S, Leduc A, Bergeron Y, Nguyen TX, Tremblay F (2007) Understory vegetation of boreal tree plantations: Difference in relation to previous land use and natural forest. *Forest Ecol Manag* 242: 49-57
- Hanawa-machi (ed) (1986) Hanawa machi shi (History of Hanawa Town), Hanwa-town, Fukushima (in Japanese)
- Iida S, Nakashizuka T (1995) Forest fragmentation and its effect on species diversity in sub-urban coppice forests in Japan. *Forest Ecol Manag* 73: 197-210
- Kamihogi A, Yamazaki A, Satou H (2002) A study of the factors in the natural and social environments which have an impact on the habitats of *Gastrosteus microcephalus*. *J Jpn Inst Landsc Architect* 65: 533-538 (in Japanese with English summary)
- Mizoguchi Y, Morisawa T, Ohtani Y (2002) Climate in Ogawa Forest Reserve. In: Nakashizuka T, Matsumoto Y (eds) *Diversity and interaction in a temperate forest community—Ogawa Forest Reserve of Japan*. Ecological Studies vol. 158, Springer, pp. 11–18
- Nakashizuka T and Matsumoto Y (2002) Diversity and interaction in a temperate forest community-Ogawa Forest Reserve of Japan. *Ecological Studies* vol. 158, Springer.
- Inoue T (2003) Chronosequential change in a butterfly community after clear-cutting of deciduous forests in a cool temperate region of central Japan. *Entomol Sci* 6: 151-163
- Okubo S, Fukamachi K, Kuramoato N (2000) Toward Conservation of Rural Landscapes. *J Jpn Inst Landsc Architect* 63: 177-207 (in Japanese)
- Society of Sociology of Law of Ibaraki University (1956) *Iriaiken no kenkyu dainisyu* (Study of common forest right, the second collection), Society of Sociology of Law of Ibaraki University, Mito
- Suzuki W (2002) Forest vegetation in and around Ogawa Forest Reserve in relation to human impact. In: Nakashizuka T, Matsumoto Y (eds) *Diversity and interaction in a temperate forest community-Ogawa Forest Reserve of Japan*. Ecological Studies vol. 158, Springer, pp. 27-41
- Taga Livestock Industry Cooperation (1982) *Taga koma shi* (History of horse breeding in Taga Country),Kyodohensyusitsu, Mito (in Japanese)
- Tokyo Regional Forest Office (1925) Second forest management plan for Takahagi District National Forests (in Japanese)
- Tokyo Regional Forest Office (1947) Sixth forest management plan for Takahagi District National Forests (in Japanese)