Characteristics in the Distribution of the Woodland Vegetation in the Southern Kanto Region since the Early 20th Century

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Abstract: We examined the changes in vegetation composition and in areas of woodlands in southern Kanto region since the early 20th century. Statistical data from ca.1910, 1980 and 2000 were used to grasp the distribution of the percentage areas of woodland vegetation. We have shown that as well as landform, other anthropogenic factors, such as industry or urbanization, also influenced woodland vegetation in spatially different ways. It is also indicated that the characteristics of satoyama landscapes in a county scale, have been becoming similar compared to those in ca.1910.

Key Words: satoyama, statistical data, woodland vegetation, county

INTRODUCTION

Satoyama, secondary woodland that historically was regularly managed by farmers is one of main parts of satoyama landscape, which is recognized as having many important functions (Fukamachi and Sakuma, 1998). Since satoyama landscape was formulated by the interaction of nature and humankind, its characteristics vary by locality. Uniqueness is becoming an important element in landscape planning. To understand differences in characteristics of satoyama landscapes by locality and their backgrounds is the first step toward conservation and creation of satoyama landscapes with their uniqueness. However, urbanization and abandonment of management of woodland have recently changed satoyama landscapes largely. The need to understand past landscapes and their changes has been recognized (Marcucci, 2000; Antrop, 2005) for the planning of landscapes. Yamamoto (2000) reported the characteristics of landscapes in the early 20th century and its change. However in terms of woodland vegetation by species, which is a major characteristic of satoyama landscape, it is not identified quantitatively in the context of longer time period especially including the time before the WWII, because of an insufficiency of data. Here, in an effort to address such deficiencies in our knowledge of changes in the vegetation of satoyama landscape, we utilized the statistical data, and examined characteristics in the spatial distribution of woodland vegetation and its change as well as area of woodland since the early 20th century.

1. METHODS

1.1 Study area

The study area (Fig. 1) was set in the southern Kanto region (Saitama, Tokyo, Chiba, and Kanagawa prefectures), Japan, where urbanization is thought to have had a great impact on the landscape and where there are a number of citizen groups that protect, use, and manage satoyama in various ways (Ministry of Environment, 2001). The region

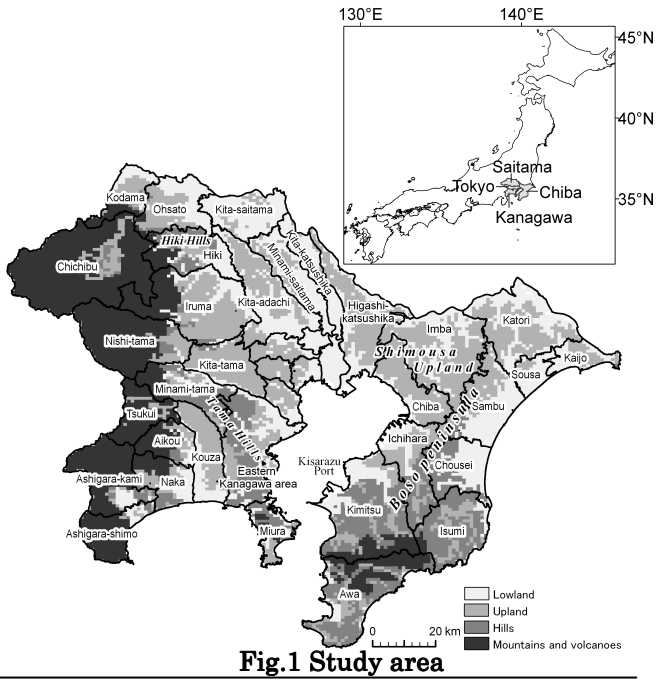

Fig.1 Study area

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includes various landforms (Fig.1). Lowland spread mainly in the middle of the region from north to south. A wide area of upland called Shimousa upland locates in the northern Boso Peninsula. Other uplands locate in the east of the mountainous area, which spread in the west of the region. There are some hilly areas for example, Tama hills in the southern central and Hiki hills in the northern central of the region.

1.2 Data preparation

Data on vegetation and area of woodland were obtained for the years ca.1910 (1905–1914), 1980, and 2000. We included private and communal woodland, but not imperial and national forests in the analysis.

1) *Fuken toukeisyo* for ca.1910 data

Data for ca.1910 were obtained from chapter of "forestry" in *Fuken toukeisyo* (Saitama prefecture, 1907-1916; Chiba prefecture, 1907-1916; Tokyo prefecture, 1907-1916; Kanagawa prefecture, 1907-1916), which is statistical yearbook that has been published by each prefecture every year since the Meiji Era. Although *Fuken toukeisyo* contains no data category that directly shows the area of woodland for each tree species, it lists "logging volume" for timber and fuel wood by tree species from 1905 to 1914; we thought this listing indicates the volume of woodland vegetation indirectly. We totalized logging volume by each species for 10-years period to minimize annual variability. We calculated the different volume units of fuel wood and timber into a same volume unit referring the guidelines of data collection for the yearbooks (Nourin daijin kanbou toukeika, 1932).

The guideline also regards tree species to be included in the "logging volume" table; however, there are small differences among prefectures and years. We assumed that the volume of tree species which did not appear in the table was not very large, and as a consequence, we combined the tree categories (Table 1). There was a category "Other species". We assumed that most of the species under this category corresponded to broad-leaved species after having examined the logging volume in the yearbooks by Chiba Prefecture, which provided the volume by separating broad-leaved species by coniferous species. Therefore, we placed this category under "Broad-leaved" species.

We converted logging volume to area by each tree species, to compare to the areas after 1980. For this, we used "growing stock per unit area" by species obtained from the Forest Resource Tables of ca.1960[2)] for 40-year-old Japanese cedar and Japanese cypress, 20-year-old pine, sawtooth oak and other broad-leaved species, and of 1990[3)] for 40-year-old other coniferous species.

Total area of woodland in 1910 was also obtained from a table in the chapter of "Forestry".

2) The Forestry census for data in 1980 and 2000

The total area and the area covered by each vegetation type were obtained from the Forestry censuses of 1980 and 2000 (Ministry of Agriculture and Forestry, 1981; 2001). Species categories were combined, as shown in Table 1.

Total woodland areas between ca.1910 and 1980-2000 were discontinuous and could not compared directly because the areas in *Fuken toukeisyo* came from tax books, while those in the Forestry censuses are the results of actual measuring.

Categories used in this study	Categories in *Fuken toukeisyo* (ca.1910)	Categories in the Forestry census of 1980 and 2000
Japanese cedar and Japanese cypress	Japanese cedar (*Cryptomeria japonica*), Japanese cypress (*Chamaecyparis obtusa*)	Japanese cedar (*Cryptomeria japonica*), Japanese cypress (*Chamaecyparis obtusa*)
Pine	Pine (*Pinus* spp.)	Pine (*Pinus* spp.) planted
Other coniferous	Japanese Fir (*Abies firma*), Hiba (*Taujopsis dolabrata*), Tsuga (*Tsuga sieboldii*), Karamatsu (*Larix leptolepis*), Momi (*Chamaecyparis pisifera*), Other coniferous	Ezomatsu and Todomatsu (*Abies* spp.), Karamatsu (*Larix leptolepis*), Pine (*Pinus* spp.) natural, Other coniferous
Broad-leaved	Sawtooth oak (*Quercus acutissima*), Evergreen oak (*Quercus* spp.), Chestnut (*Castanea crenata*), Japanese zelkova (*Zelkova serrata*), Camphor laurel (*Cinnamomum camphora*), Nara (*Quercus serrata*), Other broad-leaved, Other-species	Sawtooth oak (*Quercus acutissima*), Other broad-leaved

Table 1 Categories of tree species

3) County boundary data

County boundary datasets were created using base data of former village boundary (Gyouseikai Hsen-sen-zu database kenkyukai, University of Tsukuba[4]). We combined these boundaries for each county and included cities into counties which they had belonged to. Because there are some municipalities which several municipalities from different counties have merged into since 1950s, we prepared two boundary datasets: one for ca. 1910 and the other for 1980 and 2000, which were not equivalent but similar. The area for four counties Tachibana, Tuzuki, Kuraki and Kamakura in 1910, which corresponds to the area for present cities of Yokohama, Kawasaki and Kamakura, was combined because the boundaries between them are very different from those in ca.1910. Hereafter, we refer to these combined counties as "Eastern Kanagawa area".

4) Landform data

To grasp the natural condition of each county landform data (1-km grid) were obtained from the Japan Engineering Geomorphologic Classification Map (Wakamatsu *et al.*, 2005). Original categories were combined into four categories: lowland, upland, hills, and mountains and volcanoes.

1.3 Analysis

The percentage areas of each woodland vegetation type by county were mapped by using GIS software ArcMap ver.9.2 (ESRI, 2007), and the characteristics of their distribution were examined.

2 RESULTS

2.1 Woodland vegetation in ca. 1910

In the study area, broad-leaved species dominated 70% of the woodland area, whereas pine dominated 24% and Japanese cedar and Japanese cypress dominated 5%.

Figure 2a shows the percentage distribution of woodland types. In almost all counties, woodland comprised either broad-leaved trees, pine trees, or both. Except in counties where lowland was dominant and woodland areas were very small (Kita-saitama, Minami-saitama, and Kita-katsushika), Japanese cedar and Japanese cypress were found in relatively high percentages only in Nishi-tama (24%) and Iruma (10%) counties in the western part of study area and Sambu (11%) in Shimousa upland.

All counties where pine dominated more than 60% of the woodland were in the Shimousa Upland.

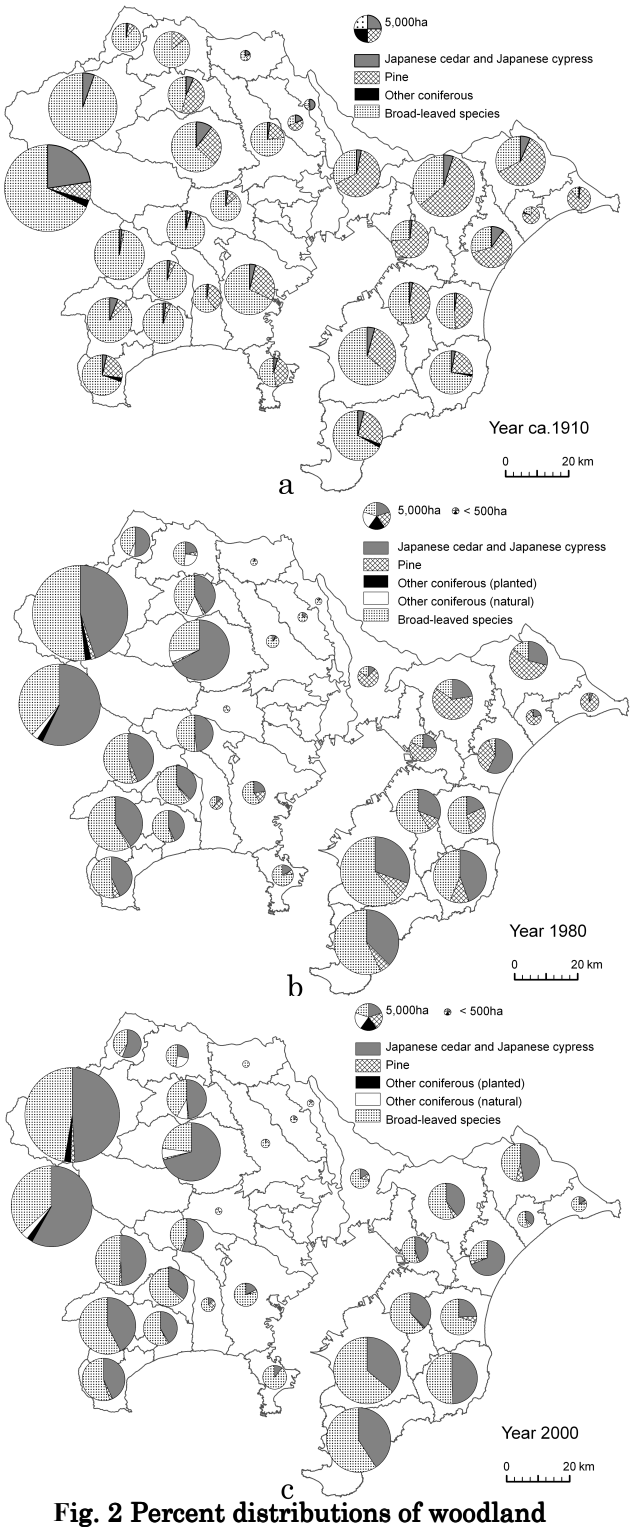

Fig. 2 Percent distributions of woodland vegetation (a, ca.1910; b, 1980; c.2000)

However, other counties where upland was dominant showed a range in the percentages of woodland types. For example, broad-leaved trees covered 86% and pine comprised only 12% of the woodland in Kita-tama county, whereas pine accounted for 38% of the woodland in Kouza county.

Counties where hills predominated also showed a range in the percentages of woodland types found. Broad-leaved woodland comprised 95% of the tree species in Minami-tama county, although in Eastern Kanagawa area, which is also mainly in the Tama Hills, pine comprised 28% of the woodland. In Hiki county in the Hiki Hills, pine and broad-leaved trees were co-dominant (48% and 46%, respectively).

2.2 Woodland vegetation in 1980

In 1980, Japanese cedar and Japanese cypress dominated the woodlands of many counties (Fig. 2b), especially in counties where mountains and volcanoes are dominant landforms such as in Chichibu, Tsukui, Aikou, and Ashigara-kami counties, and also in Minami-tama county where hills are major topographic features.

In counties in the Boso Hills, a higher percentage of Japanese cedar and Japanese cypress occurred in 1980 than in ca. 1910 while pine comprised less of the woodland cover in 1980 than in ca. 1910.

2.3 Vegetation change from 1980 to 2000

As a whole, pine cover has greatly decreased (Fig. 2c). Even in counties in the Shimousa Upland where pine once accounted for more than 60% of the woodland, pine cover has decreased to approximately 10% in 20 years. In those counties, the percentages of both Japanese cedar and Japanese cypress woodland and broad-leaved woodland have increased. Counties where pine was not a major woodland component in 1980 did not show any remarkable change in percentages of woodland vegetation between 1980 and 2000.

3 DISCUSSION

3.1 Data limitation

The woodland composition of ca.1910 and 1980 and 2000 are not easily comparable, because the map of 1910 was representative of the logging volume which did not cover all woodland area, while that in 1980 and 2000 is actual area. However, historically, broad-leaved woodland and pine woodland were typically used with a 15- to 30-years cycle of logging and growing. Thus, the use of 10-year logging volume data to represent a woodland type is considered to be reasonable to observe obvious changes. We could not use statistical analysis because of the unit “county” which did not show spatially explicit distribution to correlate with 1km mesh of landform data.

3.2 Woodland vegetation in ca. 1910

The distribution of woodland types (Fig.2a) was basically consistent with a map of vegetation in the 1880s, made by Ogura (1994). We estimate that no significant change in vegetation cover had occurred for at least 30 years before the study period. Although the resolution of our data (county) is rougher than that of Ogura, we were able to quantify the occurrence of each woodland type including minor species such as Japanese cedar and Japanese cypress.

Relatively high percentages of Japanese cedar and Japanese cypress appeared in Nishitama, Iruma and Sambu counties, which were production centers of forestry since Edo period. However, at the same time it appeared that broad-leaved species or pine were still dominant species even in those counties.

We could not find a distinct relationship between woodland vegetation and landform, except that broad-leaved woodland was predominant in counties where mountains and volcanoes dominate. Pine dominated woodland of counties in Shimousa upland in high percentages. Although pine can grow under relatively dry condition (Hayashi, 1960) such as in upland, we could not explain only by the natural condition because of other counties in uplands showed variety in its woodland vegetation. Several anthropogenic factors have been considered to influence the distribution of woodland types. Harada (2000) described that

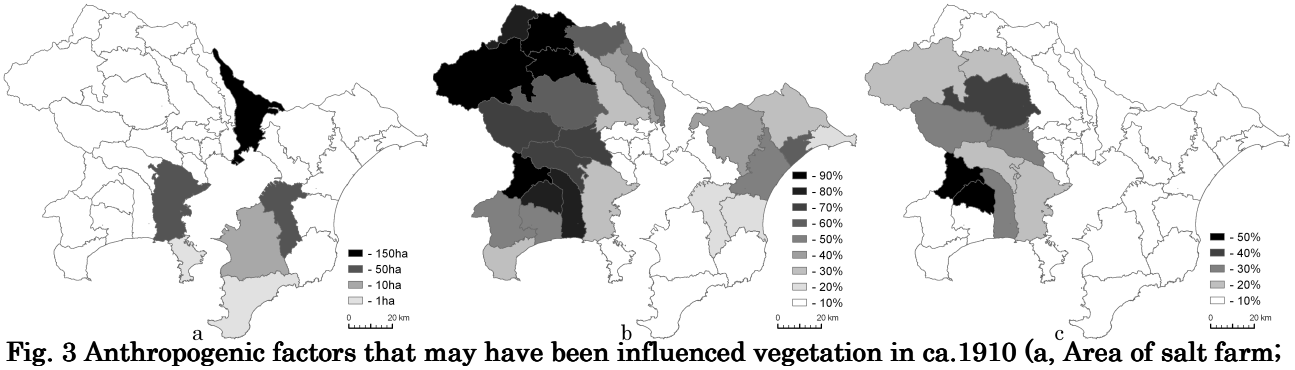

Fig. 3 Anthropogenic factors that may have been influenced vegetation in ca.1910 (a, Area of salt farm; b, percentage of silk-raising household per farm household; c, percentage of tea manufacturing household per farm household) Source: Saitama prefecture (1911, 1913); Chiba prefecture (1912, 1915); Tokyo prefecture (1912, 1913); Kanagawa prefecture (1912, 1915)

there were many pine trees in Kamakura area because of the need from salt farms. Many counties around Tokyo Bay had salt farms in ca. 1910 (Fig.3a). In particular, very large salt farms were located on the shore of Higashi-katsushika county, which may partly explain why counties in the Shimousa upland had large dominance of pine woodlands, and also why both Kouza county and Eastern Kanagawa area had a relatively large dominance of pine woodland compared to Kita-tama and Minami- tama counties. Taniguchi (1998) examined three industries that used charcoal in Iruma county during the Taisyo Era: sericulture, the tea industry, and the silk manufacturing industry. The percentage of silk-raising households (Fig.3b) and tea-manufacturing households (Fig.3c) was higher in the western Kanto region and lower in the eastern Kanto region, such as in the Shimousa Upland. We can assume that broad-leaved woodland predominated in the western Kanto region, such as in Kita-tama county, partly because of the need of charcoal made of broad-leaved species such as Sawtooth oak and Konara (*Quercus serrata*).

3.3 Woodland vegetation since 1980

We documented a significant increase in percentage covered by Japanese cedar and Japanese cypress from ca.1910 to 1980; we consider this to be a result of the process of expanded forestation that started in the 1950s. Counties that had a higher percentage of total woodland area in 1980 also had a higher percentage of Japanese cedar and Japanese cypress woodland in 1980 (Fig. 4) and were located mainly on mountain and volcanoes areas. We estimated that afforestation was promoted because of large scale of woodland. Because in ca. 1910 these counties were primarily covered with broad-leaved woodland, the deliberate planting of Japanese cedar and Japanese cypress may have occurred at the expense of broad-leaved woodland.

We also observed a decrease in pine woodland and an increase in Japanese cedar and Japanese cypress in counties in the southern Boso Peninsula. This may indicate that they were planted at the expense of pine trees as well as broad-leaved trees. Pine disease entered the area through Kisarazu port in Kimitsu county in the late 1970s, and those lands where pines died from the disease or were cut to avoid this have been subsequently used as plantation areas. On the other hand, a decrease in the area of pine woodland was not observed in the counties of the Shimousa Upland. Pine disease started in Kisarazu and spread to the Shimousa Upland. It seemed that Shimousa Upland had not yet been affected by this disease in the 1980s.

Counties located closer to central Tokyo, where the woodland area was less, supported only a small percentage of Japanese cedar and Japanese cypress woodland (Fig. 4). Urbanization around woodland areas is thought to have precluded new forest management.

From 1980 to 2000, a drastic change in vegetation occurred, particularly around the Boso Peninsula, as a result of pine disease. In the Shimousa Uplands, where the percentage of pine woodland had remained

unchanged up until 1980, the area of pine woodland decreased by more than 50%. At the same time, the percentage of the woodland area covered by Japanese cedar and Japanese cypress increased. In these counties, residential growth slowed after 1980, and the decrease in woodland cover ceased. We consider that pine disease and the presence of a certain amount of woodland promoted afforestation of Japanese cedar and Japanese cypress. However, not all woodland affected by pine disease was planted with Japanese cedar and Japanese cypress, because broad-leaved woodland cover also increased, probably the result of succession after pine woodland that had died or been cut.

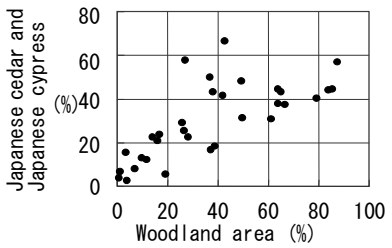

Fig.4 Relationship between woodland area and percentage of Japanese cedar and Japanese cypress

Although the counties in the Boso Peninsula experienced a dramatic change in vegetation type after 1980, the mountain and volcano areas and the hills of the western Kanto region, which experienced substantial change before 1980, did not show a remarkable change in percentages of woodland composition after 1980. We considered that it is possible to say that without pine disease, afforestation did not occur. In addition, vegetation changes in the upland areas except Shimousa upland and lowland areas were also small.

We have described here the long-term changes in difference in characteristics of woodland vegetation by locality in the southern Kanto region. In ca.1910, there was a clear difference in woodland vegetation by locality, which we thought landform and several industries has influenced to some extent. This difference however has been lost until today as a result of socio-economic change and natural disaster such as expanded forestation and pine disease. Further analysis on representative types of vegetation change shown in this study and of landscapes on the precise scale as well as in more detailed context such as urban, sub-urban, and agricultural will enable deeper understanding of historical changes of satoyama landscapes. Although present study focused only on woodland in satoyama landscape, the result that its difference by locality has been lost indicates to some extent that historical understanding of difference in landscape by locality is an important basis of the planning of satoyama landscape with its uniqueness.

ACKNOWLEDGEMENTS

This research was partly supported by the 21st Century COE Program, Biodiversity and Ecosystem Restoration. We thank Mr. Terashima of Chiba prefecture and Mr. Sato of Tokyo prefecture who provided us Forest Resource Tables and other useful materials.

NOTES

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