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Comparison of Landscape Structure in the 1880s and the 1980s at Five Areas of the Boso Peninsula, Central Japan

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Abstract We compared the landscape structure in the 1880s and the 1980s at five areas in the Boso Peninsula, central Japan: Yokaichiba (coastal plain area), Kobayashi (inland lakeshore plain area), Chiba-tobu (dissected diluvial plateau area), Amaariki (hilly area) and Ootaki (mountainous area). In the 1880s, the relative dominances of paddy field and pine forest were high in the coastal plain, the lakeshore plain and the dissected diluvial plateau areas, which were located on the northern part of the Boso Peninsula. The hilly area was characterized by dominance of pine forest and grassland vegetation. The mountainous area was characterized by dominance of deciduous broad-leaved forest, pine forest and grassland vegetation. These two areas, which were located on the southern part of the Boso Peninsula, were characterized as a mosaic landscape consisting of forest, scrub and grassland. In the 1880s, most of the land-cover had been affected by human impact, but there were regional differences in landscape structure. In the coastal and lakeshore plain, paddy fields predominated, but the relative dominance of pine forest decreased during about 100 years. In the dissected diluvial plateau area, the relative dominance of residential area had increased greatly due to urbanization. In the hilly area, deciduous broad-leaved and evergreen broad-leaved forests became dominant. In the mountainous area, the relative dominance of deciduous broad-leaved forest increased, whereas those of mixed grassland and pine forest decreased. These changes in the mountainous area seem to have resulted from succession due to the cultivated fields, grassland and forest in the region no longer being managed.

Key words: Landscape ecology, regional differences, old military map (Jinsokuzu-genzu), modern vegetation map (actual vegetation map), succession, human impact.

Change in landscape structure is one of main themes of landscape ecology (Forman and Godron, 1986). To clarify the changes in landscape structure, vegetation maps based on remote sensing techniques are frequently used (Naveh and Lieberman, 1994; Haines-Young *et al.*, 1993). However, it is difficult to make landscape maps for the time when satellite data and aerial photographs were not available. Historical maps, paintings and documents are an alternative way of reconstructing former vegetation (Rackham, 1986, 1998). Carni *et al.* (1998) compared the past and present forest vegetation in northeast Slovenia using different kinds of map, including old military, cadastral and modern vegetation maps. It is, however, difficult to reconstruct the distribution of past vegetation distribution over large areas based on documents, paintings and old photographs or similar, because the information obtainable from them is limited to local spots (Harada *et al.*, 1998).

Land use maps of Japan in 1850 have recently been made using old topographical maps (Himiyama *et al.*, 1995). Based on such maps, Arizono (1994) concluded that energy circulation and sustainable ecosystems were still maintained within a local community in ca. 1850 (late Edo era) in most of Japan. Although these maps can be used as country-wide physiognomic vegetation maps, their relatively coarse scale and categories of land-cover type are insufficient for analysis on the meso- and micro-scales.

Ogura (1993a, b; 1994) showed that mili-

tary maps, "Jinsokuzu" and "Jinsokuzu genzu", made between 1880 and 1886 for the Kanto district were useful for reconstructing the past vegetation. In these old military maps, not only were land use types such as paddy fields, arable fields and grassland distingished, but also the dominant tree species such as *Castanopsis sieboldii* and *Quercus acutissima*. Harada and Harada (1995, 1997) and Harada *et al.* (1998) analyzed vegetation changes in Yokohama City based on a comparison of a vegetation map with the old military maps which proved to be useful data sources for the tracing the history of vegetation and human impact on the meso- and micro- scales.

Landscape structure is maintained or changed under a balance between natural and anthropogenic disturbances (Kamada and Nakagoshi, 1996). The human land use pattern and the natural disturbance regime vary locally in relation to social and natural circumstances (Turner, 1990; Kamada and Somiya, 1995; Kamada and Nakagoshi, 1996, 1997). A comparative approach can specify the factors that make a local landscape unique (Turner and Ruscher, 1988).

The comparison of landscape structures in different regions is one of the important theme of landscape ecology. In this paper, we used old maps to reconstruct the former vegetation and to elucidate subsequent changes in land use pattern over about 100 years in five different areas on the Boso Peninsula, central Japan. We then compare the changes in landscape structure in the five areas and discuss the characteristics of human land use and disturbance which had lead to the structural differences in these landscapes.

Study Area and Methods

The Boso Peninsula is located in the southern part of Kanto district, central Japan and falls into two different areas from the topographical viewpoint. The northern part of the peninsula consists of alluvial lowlands along the Kujyukuri Coast, Tone River, Edo River and Tokyo Bay and diluvial plateau such as the Shimosa upland. In contrast, the southern part consists of hilly and mountainous areas such as the Boso Hills. The mean annual temperature on the peninsula ranges from 13.7℃ to 15.6℃ (Japan Meteorological

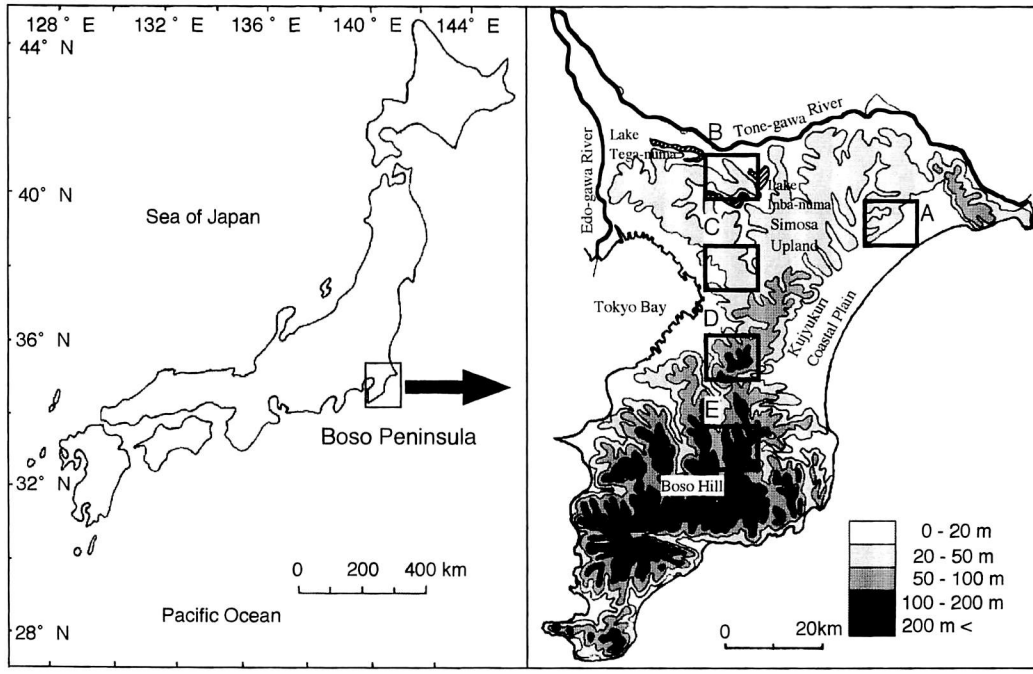

Fig. 1. Location of study areas. A, Yokaichiba, coastal plain; B, Kobayashi, inland lakeshore plain; C, Chiba-tobu, dissected diluvial plateau: D, Amaariki, hill; E, Ootaki, mountainous.

Agency, 1995). Annual precipitation ranges from 1280 to 2340 mm, with values increasing from north to south (Japan Meteorological Agency, 1995). The present population density is the highest in the northwestern part neighboring the Tokyo metropolis.

We selected five study areas on the Boso Peninsula; Yokaichiba, Kobayashi, Chiba-tobu, Amaariki and Ootaki (Fig. 1). The Yokaichiba area comprises the Kujyukuri Coastal Plain and the north-east part of the Shimosa Upland. The Kobayashi area comprises part of Lake Inba, the alluvial plain along the Tone River and the northern part of the Shimosa Upland. The Chiba-tobu area comprises the southern part of the Shimosa Upland and the alluvial plain along Tokyo Bay. These three areas are all less than 50 m in altitude. The Amaariki area comprises the northern part of the Boso Hills and ranges from 5 to 173 m in altitude. The Ootaki area comprises the central part of the Boso Hills and ranges from 30 to 250 m in altitude. Each of these study areas corresponds to one sheet of the 1 : 25,000 scale topographical map (ca. 9×11 km) issued by the Geographical Survey Institute.

We used two sets of maps in the analysis; old military maps called "Jinsokuzu-genzu" and modern vegetation maps. The former were made between 1880 and 1886 on a scale of 1 : 20,000, and the latter were made between 1979 and 1981 on a scale of 1 : 50,000. In order for both to be on the same scale, the military maps were reduced to, and the modern vegetation maps were enlarged to, 1 : 25,000.

For the analysis, the land-cover categorization largely followed Ogura (1993a, b), but some categories were modified in order to coordinate the two sets of maps (Table 1). Seven types of woody vegetation were recognized; evergreen broad-leaved forest, deciduous broad-leaved forest, pine forest, Japanese cedar forest, mixed forest, bamboo forest and scrub. Grassland was divided into two types; mixed grassland and *Miscanthus sinensis* grassland. Six types of cultivated land were recognized; tea field, mulberry field, arable field, abandoned arable field, paddy field and abandoned paddy field. Inhabited land and other types of urban land use were combined into the residential area. In addition, bare ground, aquatic plant community and open water were recognized. The remaining land-cover types were put together into "others". A total of twenty land-cover types were recognized in the present study.

Each study area was divided into 100 (10×10) grid cells, according to latitude and longitude. The dimension of each grid cell was about 1 km^2 (0.9×1.1 km). In each grid cell, all land-cover types were inventoried and the most abundant one was determined to be the dominant land-cover. In each study area the relative dominance (RD) and frequency (FQ) of each land-cover type were calculated as follows:

$$RD_A(\%) = ND_A / TN \times 100$$

where RD_A is the relative dominance of land-cover type A, ND_A is the number of grid cells in which land-cover type A dominated, and TN was the total number of grid cells. In the case of this study, TN was 100:

$$FQ_A(\%) = NE_A / TN \times 100$$

where FQ_A is the frequency of land-cover type A, NE_A is the number of grid cells in which land-cover type A existed and TN is the total number of grid cells.

The similarity index (SI) of landscape structure between the 1880 and the 1980s was calculated as follows:

$$SI = \Sigma \min (p_{1880} \text{ or } p_{1980})$$

where p_{1880} and p_{1980} were the relative dominance of each land-cover type in the 1880s and 1980s. This index ranges from 0 to 100.

Results

1. Change in landscape structure in Yokaichiba, the coastal plain area

In the 1880s, paddy field (58%) was the most dominant land-cover type in the coastal plain (Fig. 2-A). Almost all grid cells (97%) were dominated by paddy field, pine forest (24%) or arable fields (15%). This pattern was not essentially changed in the 1980s. The sum of the grid cells where one of these three types was dominant still reached 95% in the 1980s (Fig. 2-A). However, there was a marked decrease in the dominance of pine

Table 1. Correspondence of the land-cover categorization used in the present study to those of old military map and actual vegetation map. Terms in parentheses mean Japanese terminology used on old military map.

Present study	Old military map (Jinsokusokuzu-genzu)	Actual vegetation map
Woody vegetation		
Evergreen broad-leaved forest	*Castanopsis sieboldii;* Evergreen *Quercus* (Kashi); *Castanopsis sieboldii* and evergreen *Quercus*	*Ardisio-Castanopsietum sieboldii; Rumohro-Castanopsietum sieboldii*
Deciduous broad-leaved forest	*Quercus acutissima;* Deciduous *Quercus* (Nara)	*Quercus serrata* community; *Q. acutissima* plantation; *Acero-Zelkovetum*
Pine forest	Pine	*Pinus densiflora* community; *Pinus* plantation
Japanese cedar forest	Cedar	*Cryptomeria japonica, Chamaecyparis obtusa* and *C. pisifera* plantation
Mixed forest	Mixed forest (Zatsujurin); *Castanopsis sieboldii* and pine; Pine and deciduous *Quercus*	*Zelkova serrata-Quercus myrsinaefolia* community
Scrub	Barrens or wasteland (Kouya); Scrub (Koubuchi, Kanbokuchi; Bokusou)	—
Bamboo forest	Bamboo	Bamboo forest; *Pleiobrastus simonii* community
Grassland vegetation		
Mixed grassland	Grassland (Souchi)	Cultivated meadow; Golf links; Weed communities of the roadside; Plant communities in clear-cut area
Miscanthus sinensis grassland	*Miscanthus sinensis* grassland (Kaya)	*Arundinario chino-Miscanthetum sinensis; Imperata cylindrica* var. *koenigii-Miscanthus sinensis* community
Cultivated land		
Tea field	Tea field	—
Mulberry field	—	Mulberry garden
Arable field	Arable field	Field weed community
Abandoned arable field	—	*Erigeron canadensis-Erigeron sumatrensis* community
Paddy field	Paddy field	Paddy-field weed communities
Abandoned paddy field	—	Weed communities in uncultivated paddy-field
Inhabited land		
Residential area	Marks of houses; Trainning field for army (Renpeijo)	Urban district with a few trees; Urban and residential district with many trees; Factory and industrial area; Land constructed for residence and factory
Other land-cover types		
Bare ground	—	Natural bare land
Aquatic plant community	Marsh	Phragmitetea
Open water	River; Pond	Open water
Others	Sand	Deciduous orchard; Nursery garden; Forest for environment conservation

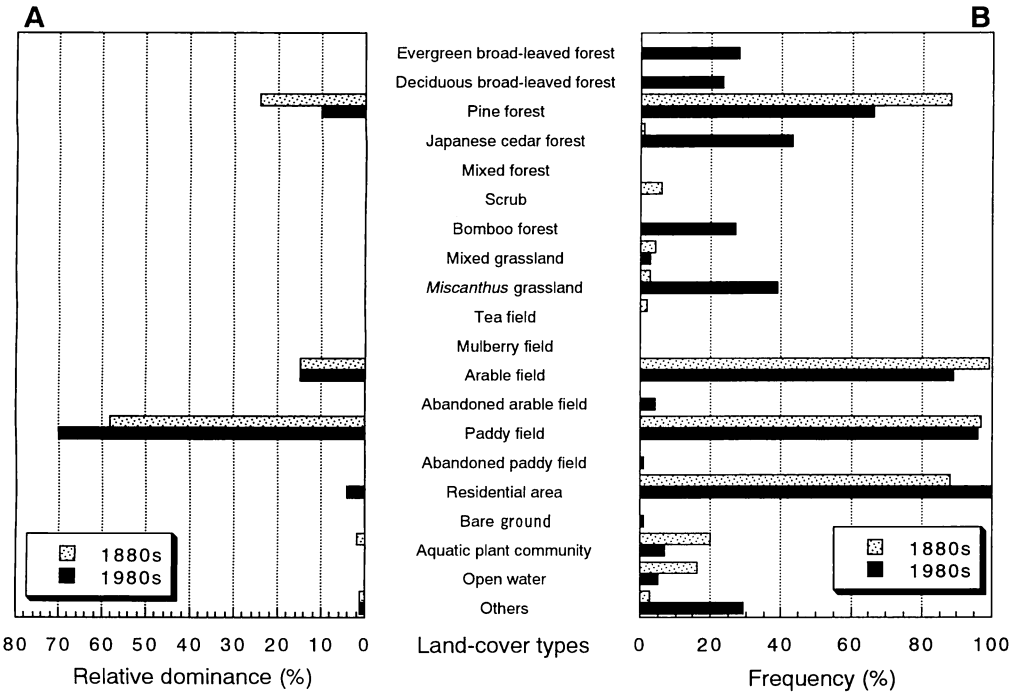

Fig. 2. Relative dominance (A) and frequency (B) of each land-cover type in Yokaichiba (the coastal plain area) in the 1880s and 1980s.

forest. Pine forest-dominated cells in the 1980s were less than half those in the 1880s. Residential area had newly become the dominant land-cover type in 4% of the cells.

Changes in frequency were more obvious (Fig. 2-B). In the 1880s, arable field, paddy fields, pine forest and residential area were found in more than 80% of the grid cells. Aquatic plant community and open water, which were back marsh components, were found in 20–16% of the cells. Other minor components with less than 10% frequency included Japanese cedar forest, scrub, mixed grassland, *Miscanthus sinensis* grassland and tea field. On the other hand, in the 1980s, residential area, paddy field and arable field remained more frequent than 80%. However, the frequency of pine forest decreased from 88% to 66%. Some formerly absent or nearly absent forest types including Japanese cedar (43%), evergreen broad-leaved (28%), deciduous broad-leaved (23%) and bamboo (27%) forests increased very markedly. *Miscanthus sinensis* grassland also increased to 39%, while mixed grassland remained infrequent. Wetland components, aquatic plant community and open water, decreased to less than 10%.

2. Change in landscape structure in Kobayashi, the lakeshore plain area

In the 1880s, pine forest (36%) and paddy field (35%) were co-dominant land-cover types in the lakeshore plain (Fig. 3-A). Open water dominated in the 12% of the cells. Minor components accounting for less than 10% were arable field (9%), *Miscanthus sinensis* grassland (3%), deciduous broad-leaved forest (2%) and aquatic plant community (2%). In the 1980s, grid cells where pine forest was dominant decreased to less than half of the 1880s value as, as in the coastal plain (Fig. 3-A). The relative dominance of both open water and aquatic plant community also decreased. On the other hand the relative dominance of cultivated land such as paddy field and arable field increased. Residential area, Japanese cedar forest and mixed grassland became the dominant land-cover types.

In the 1880s, arable field, paddy field and pine forest were found in more than 80% of

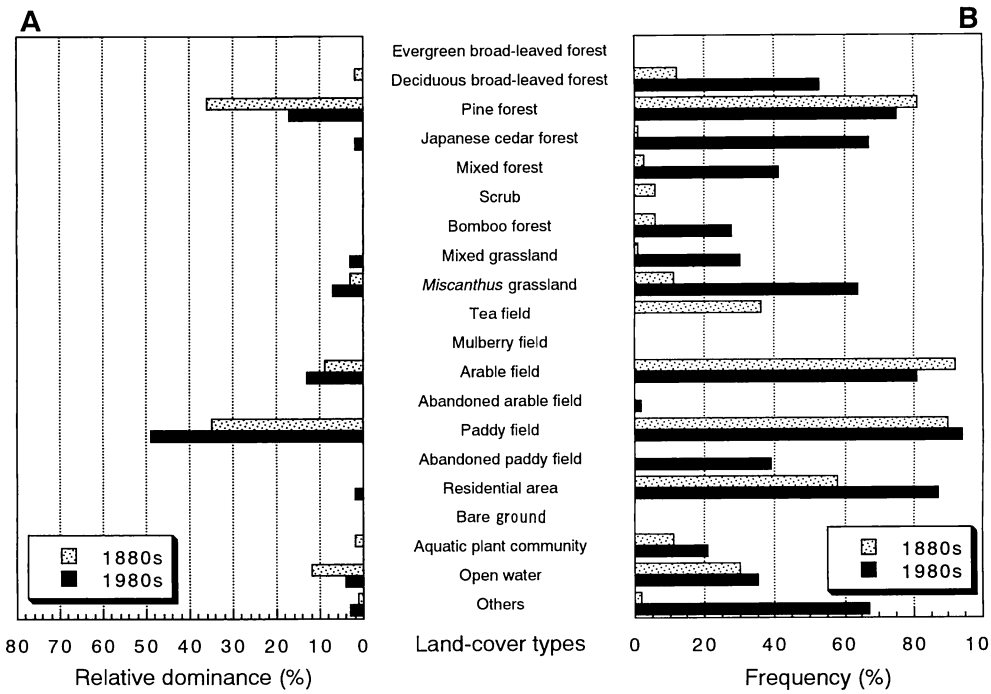

Fig. 3. Relative dominance (A) and frequency (B) of each land-cover type in Kobayashi (the inland lakeshore plain area) in the 1880s and 1980s.

the grid cells (Fig. 3-B). The frequency of residential area also reached 58%. Tea field (36%) and open water (30%) were present. Many kinds of minor components were found in this area. In the 1980s, high frequencies were retained by paddy field (94%), arable field (81%) and pine forest (75%) (Fig. 3-B). The frequency of residential area increased to 87%. Woody vegetation such as Japanese cedar (67%), and deciduous broad-leaved (53%), mixed (41%) and bamboo (28%) forests and grasslands (mixed and *Miscanthus sinensis* grasslands) became common land-cover types. The frequency of mixed grassland increased due to the construction of new golf courses. Tea field had disappeared in this area. Abandoned paddy fields (39%) and abandoned arable fields (2%) appeared in the 1980s.

3. Change in landscape structure in Chibatobu, the dissected diluvial plateau area

In the 1880s, pine forest (65%) was the most dominant land-cover type in the dissected diluvial plateau area (Fig. 4-A). The relative dominance of paddy field was 25%, while values for arable field, residential area, deciduous broad-leaved forest and mixed forest were all less than 5%. This pattern had changed markedly by the 1980s. The relative dominance of pine forest decreased to less than 10%, whereas residential area (46%) became the most dominant land-cover type in the 1980s (Fig. 4-A). Arable field and paddy field dominated, respectively, in 20% and 19% of the grid cells. In the 1980s, the relative dominance of woody vegetation was the lowest and that of residential area was the highest of the five study areas.

In the 1880s pine forest, arable field and paddy field were found in more than 90% of the cells (Fig. 4-B). The frequencies of the residential area (60%) and tea field (33%) were relatively high. In the 1980s the frequency of residential area increased from 60% to 96% (Fig. 4-B). The high frequencies of arable fields and pine forest were maintained (>90%), while the frequency of paddy field decreased. Japanese cedar forest (79%) and deciduous broad-leaved forest (69%) became one of the most common land-cover types. *Miscanthus sinensis* grassland (45%),

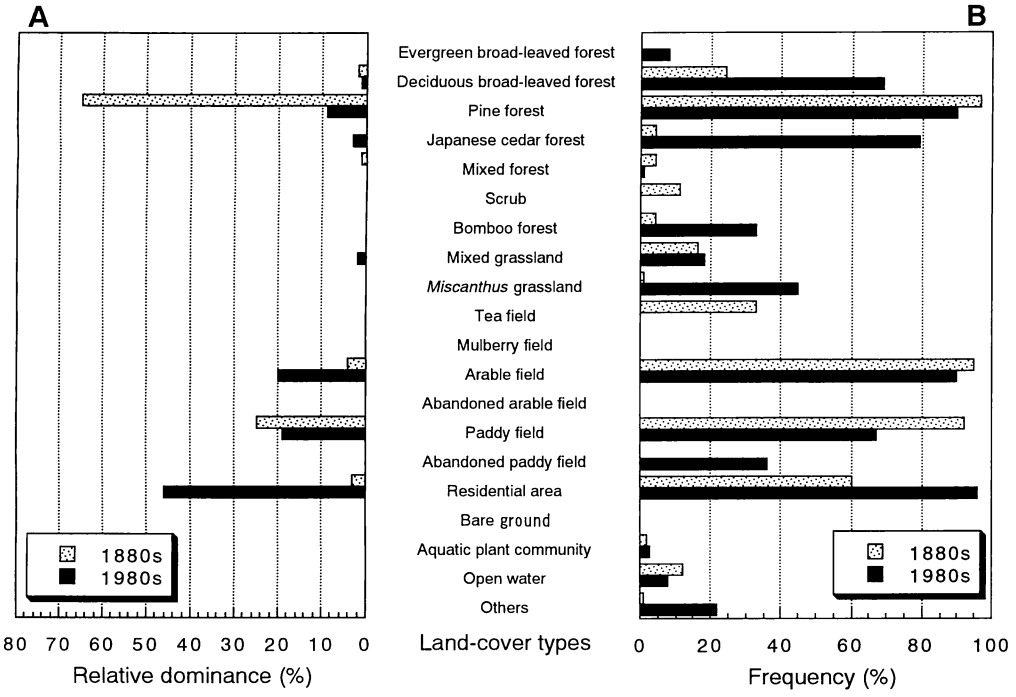

Fig. 4. Relative dominance (A) and frequency (B) of each land-cover type in Chiba-tobu (the dissected diluvial plateau area) in the 1880s and 1980s.

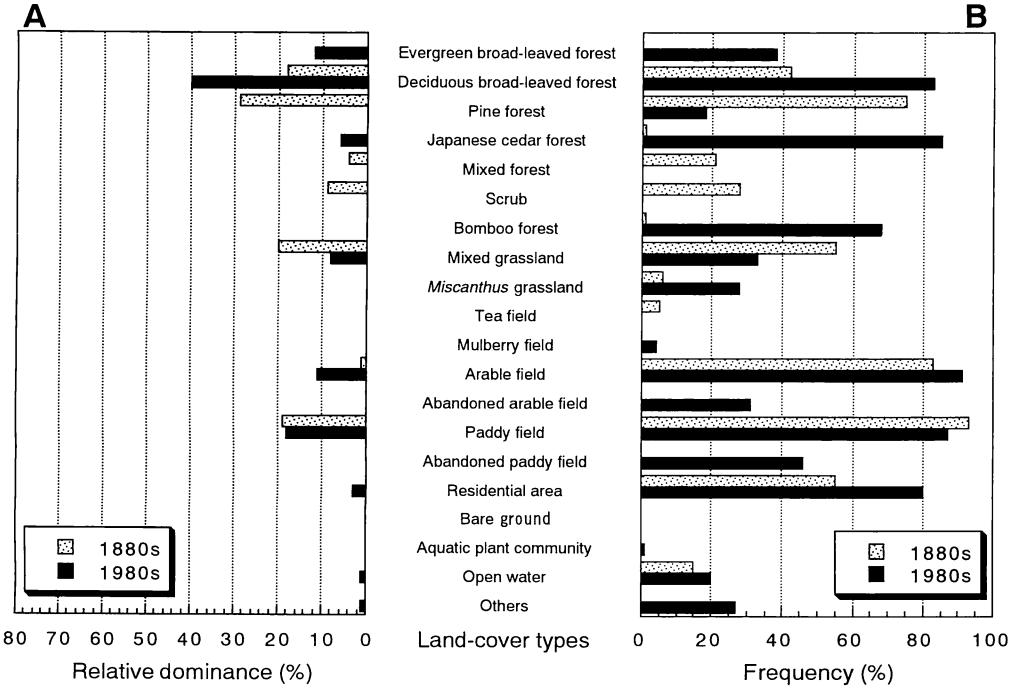

Fig. 5. Relative dominance (A) and frequency (B) of each land-cover type in Amaariki (the hilly area) in the 1880s and 1980s.

bamboo forest (33%) and abandoned paddy field (36%) occurred frequently.

4. Change in landscape structure in Amaariki, the hilly area

In the hilly area, many types of dominant land-cover shared dominance in the 1880s (Fig. 5-A); pine forest (29%), mixed grassland (20%), paddy field (19%), deciduous broad-leaved forest (18%), scrub (9%) and mixed forest (4%). In the 1980s the relative dominance of deciduous broad-leaved forest increased from 18% to 40% and evergreen broad-leaved forest (12%) and Japanese cedar forest (6%) were new additions to the dominant types (Fig. 5-A). On the other hand the relative dominance of pine forest decreased markedly from 29% to 0%. The relative dominance of mixed forest, scrub and mixed grassland also decreased. The relative dominance of paddy fields (18%) did not show a large change, but that of arable fields increased.

In the 1880s, the frequencies of paddy field (93%), arable field (83%) and pine forest (75%) were high (Fig. 5-B). Residential area occurred in 55% of the cells. The frequencies of mixed grassland, deciduous broad-leaved forest, scrub and mixed forest exceeded 20%. These values were higher than those in the plain areas of the present study. In the 1980s, the frequencies of arable field (91%) and paddy field (87%) were still high (Fig. 5-B). The frequency of residential area increased from 55% to 80%. The frequencies of Japanese cedar forest (85%), deciduous broad-leaved forest (83%), bamboo forest (68%) and evergreen broad-leaved forest (38%) increased markedly. The frequencies of mixed forest, scrub and mixed grassland decreased, while that of *Miscanthus sinensis* grassland increased. The frequencies of abandoned paddy (46%) and abandoned arable (31%) fields were high. Tea field disappeared, while mulberry field appeared. However, all the mulberry fields have now been.

5. Change in landscape structure in Ootaki, the mountainous area

In the 1880s the relative dominance of deciduous broad-leaved forest (39%) was highest in the mountainous area (Fig. 6-A),

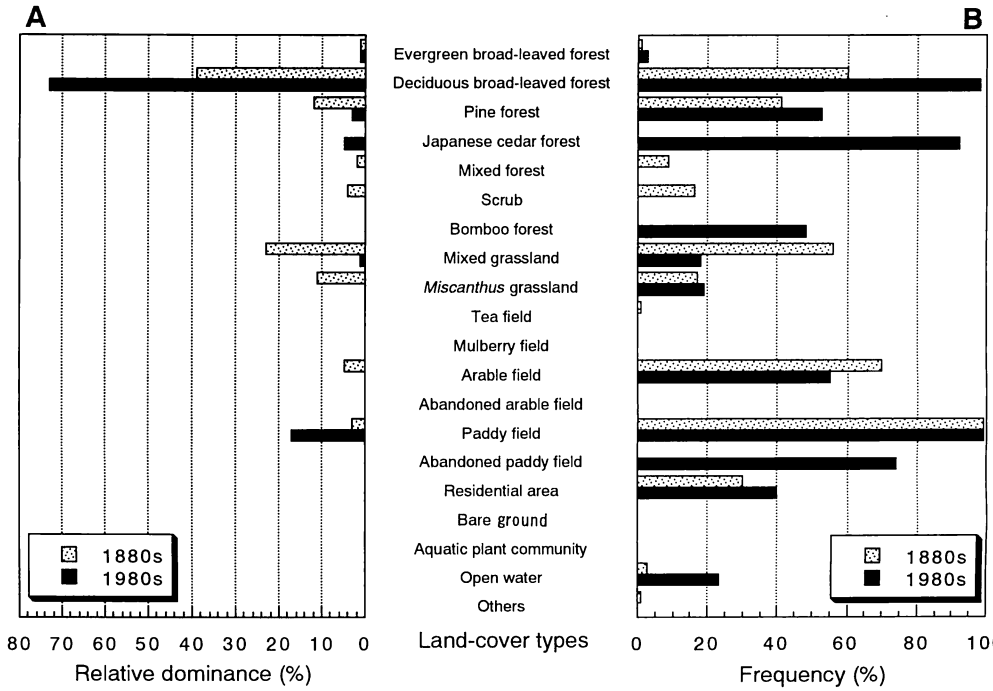

Fig. 6. Relative dominance (A) and frequency (B) of each land-cover type in Ootaki (the mountainous area) in the 1880s and 1980s.

followed by mixed grassland (23%), pine forest (12%) and *Miscanthus sinensis* grassland (11%). The sum of the relative dominance for woody vegetation types and grassland types was 58% and 34% respectively. Residential area was not found as a dominant land-cover type.

In the 1980s woody vegetation types dominated in more than 80% of grid cells. The relative dominance of deciduous broad-leaved forest was especially high (Fig. 6-A). On the other hand the relative dominance of grassland types decreased from 34% in the 1880s to 1% in the 1980s. Arable fields were not dominant in any grid cells in the 1980s.

In the 1880s paddy fields (99%) were found in almost all grid cells (Fig. 6-B). The frequency of arable fields was also high (70%). Among woody vegetation types, the frequencies of deciduous broad-leaved forest (60%) and pine forest (41%) were high. Grasslands such as mixed grassland (56%) and *Miscanthus sinensis* grassland (17%) and woody vegetation such as scrub (16%) and mixed forest (9%) were also found. The frequency of residential area was the lowest (30%) among the five study areas in the present study.

In the 1980s the frequency of paddy fields (99%) was high as it was in the 1880s (Fig. 6-B). The frequency of abandoned paddy fields (74%) was the highest among the five study areas. The frequency of woody vegetation increased, especially deciduous broad-leaved forest (98%) was found in almost all cells, reaching the highest value among the five study areas. The frequencies of cedar forest, pine forest and evergreen broad-leaved forest also increased, but the frequencies of mixed forest, scrub and mixed grassland decreased.

6. Comparison of the landscape structure among areas

Table 2 summarizes the dominant land-cover types in each area, in the 1880s and the 1980s. In Yokaichiba (the coastal plain area) the most dominant land-cover type was paddy field both in the 1880s and the 1980s. In Kobayashi (the inland plain area) the increase of the relative dominance of paddy fields and the reduction of the relative dominance of pine forest occurred. These two areas were located in the northern part of the Boso Peninsula. In Chiba-tobu (the dissected alluvial plateau area) the relative dominance

Table 2. Dominant land-cover types (relative dominance >10%) in each study area, showing a comparison of the results for the 1880s and the 1980s.

Area	Land form	Dominant land-cover types	
		1880s	1980s
Yokaichiba	Coastal plain area	Padddy field Pine forest Arale field	Paddy field Arable field Pine forest
Kobayashi	Inland plain area	Pine forest Paddy field Open water	Paddy field Pine forest Arable field
Chiba-tobu	Dissected plateau	Pine forest Paddy field	Residential area Arable field Paddy field
Amaariki	Hill area	Pine forest Mixed grassland Paddy field Deciduous broad-leaved forest	Deciduous broad-leaved forest Paddy field Evergreen broad-leaved forest Arable field
Ootaki	Mountainous area	Deciduous broad-leaved forest Mixed grassland Pine forest *Miscanthus* grassland	Deciduous broad-leaved forest Paddy field

Table 3. Similarity of landscape structure between the 1880s and the 1980s.

Area	Land form	Similarity index (%)
Yokaichiba	Coastal plain area	84
Kobayashi	Inland plain area	69
Chiba-tobu	Dissected plateau area	36
Amaariki	Hill area	45
Ootaki	Mountainous area	47

of the residential area increased markedly. In Amaariki (the hilly area) and Ootaki (mountainous area), which are located in the southern part of the Boso Peninsula, the relative dominance of pine forest and grassland decrease, while that of deciduous broad-leaved forest increased.

Table 3 compares the landscape structure in each area based on relative dominance in the 1880s and the 1980s. The similarity index shows the highest value in the coastal plain area and the lowest value in the dissected plateau area. This means that the landscape structure in the dissected plateau area changed markedly, while that in the coastal plain area was quite similar in the 1880s and 1980s. The indices show lower values in the two areas (Amaariki and Ootaki) located in the southern part than areas in the northern part, except for the dissected alluvial plateau area. The landscape structure in the southern part changed more than in the northern part.

Discussion

1. Vegetation in the 1880s

The potential natural vegetation in mesic sites of the Boso Peninsula is considered to be mainly evergreen broad-leaved forest (Miyawaki, 1986). However, at the present time, the man-made land-cover such as residential area, paddy field, arable field and pine forest, which all result from, or are influenced by human impact, covered almost all of the area. This study showed that evergreen broad-leaved forest was already quite limited in the 1880s. Paddy field, arable field, pine forest, deciduous broad-leaved forest and grassland were dominant in the study areas. Paddy and arable fields were cultivated and man-made land-cover types. Pine forest was the most dominant forest type in the northern part of the study area and the hilly area (Amaariki) in the southern part. These pine forests seem to have been short and sparse, because illustrations drawn on the old military maps in the areas show short and sparse forests. Also in the mountainous area, the area of evergreen broad-leaved natural forest was already small on the old military map. Deciduous broad-leaved and pine forests were dominant. It is considered that pine forest, deciduous broad-leaved forest and grassland were also affected by human impact, because temperature and precipitation in most of the study areas seem to be suitable for evergreen broad-leaved forest. Thus, most of land-cover types were affected by human activities and well-developed forests seemed already to have been rare in the 1880s.

Ogura (1995a, b) investigated the height of vegetation in Kanto district between the 1800s (late Edo era) and the 1880s (middle Meiji era) based on illustrations of old military maps (Jinsokuzu) and photographs. He also concluded that vegetation was generally shorter in the 1880s in the Boso Peninsula than at the present, and the forest floor was considered to be well-lit because the canopy layer was sparse (Ogura, 1995a, b).

2. Regional differences in landscape structure in the 1880s

Regional differences in landscape structure were found in the 1880s between the three northern areas (coastal and lakeshore plains and dissected diluvial plateau area) and the two southern areas. Paddy fields and pine forests predominated in the three northern areas (Table 2). These three areas are characterized by alluvial plain and Shimosa upland. On the other hand, in the southern part, the hilly area was characterized by dominance of pine forest and mixed grassland and the mountainous area by dominance of deciduous broad-leaved forest, pine forest and grassland vegetation (Table 2). These two areas are characterized by the Boso Hills. In these two areas, many kinds of woody and grassland vegetation were frequent and formed a mosaic landscape consisting of forests, scrub and grassland. A

mosaic landscape is established where a mixture of local ecosystems or land use is repeated in a similar form over an area several kilometers wide (Forman, 1995). Although all of these land-cover types were maintained by disturbance such as human activities, landscape structures were different from each area. In paticular, the landscape structure differed between northern and southern parts, depending on the topography.

3. Regional differences in landscape change

The similarity of landscape structure between the 1880s and 1980s was higher in the northern than the southern part, except for the dissected alluvial plateau area. In the coastal and inland plain areas, the relative dominance and frequency of pine forest decreased during the 100 years, while the frequencies of deciduous broad-leaved and Japanese cedar forests increased. The relative dominance of aquatic plant communities and open water decreased. This means that most natural and semi-natural vegetation along rivers and ponds had disappeared due to embankment construction. In the coastal and inland plain areas paddy field predominated during the 100 years.

In the hilly and mountainous areas, the relative dominance of deciduous broad-leaved forest, such as *Quercus serrata* forest and evergreen broad-leaved forest, such as *Castanopsis sieboldii* forest, increased, while the relative dominance of grasslands decreased. The dominant land-cover changed from grasslands to forests and from pine forest to deciduous broad-leaved forest, respectively. This change seems to have been caused by the reduction of human disturbances such as, mowing, land clearance and clear-cutting. After being abandoned natural succession seems to have occurred. In the hilly area, the frequency of cedar plantation was high (85%), while its relative dominance was low (6%). This indicates that the areas of cedar plantation are small. On the other hand, the areas of evergreen broad-leaved forests seem to be large, because both frequency and relative dominance were high. Semi-natural grassland disappeared, while artificial grassland, such as golf courses was established.

In the dissected diluvial plateau area the similarity shows the lowest value among the five areas. The relative dominance of pine forest decreased, while that of residential area increased. This means that clear cutting for the construction of houses has occurred (Fujihara, 1997). Harada and Harada (1997) documented that most deciduous oak (*Quercus serrata* and *Q. acutissima*) and pine forests, which were the dominant vegetation types around the 1880s (Meiji era), disappeared owing to human intervention in Yokohama City, Kanto district, central Japan. In the present study, the landscape structure in the dissected diluvial plateau area changed drastically due to urbanization during the 100 years. However, several small patches of these forests changed to well-developed forests due to progressive succession in Yokohama City (Harada and Harada, 1997). In the present study the frequencies of evergreen and deciduous broad-leaved forests also increased. Fujihara (1997) showed that many pine forests had changed to broad-leaved forests in Chiba City. In the dissected diluvial plateau area, where urbanization proceeded, the abandonment of cultivation and forest management also occurred.

4. Socio-economics and landscape structure

Isogai (1989) examined the distribution of evergreen broad-leaved and deciduous broad-leaved forests of the Boso Peninsula in the 1980s and concluded that both types were distributed according to temperature on the meso-scale. However, on the micro-scale the distribution of deciduous broad-leaved forest in the 1980s was similar to the distribution of grassland and pine forest in the 1880s based on old military maps (Isogai, 1989). Past land use seems to affect the present vegetation. Land use history depending on socio-economics is an important factor for the analysis of present landscape structure. Shirai (1992) established that three fundamental land use types, residential, cultivated and woodland, used to be found within a relatively small area, so the residents could obtain essential materials from the local vicinity in the northern part of

Boso Peninsula until the 1960s. Most energy and materials were derived from woodlands around the residential area. Farmland landscape consisted of these three land use types. Arizono (1994) showed that essential energy and materials had been obtained from the vicinity, and that a sustainable ecosystem had been maintained within a small area since circa 1850 (late Edo era) on the basis of the land use maps for the 1880s in Japan. During the 100 years, the energy source changed from fuelwood obtained from the vicinity to petroleum obtained from outside the vicinity. Material circulation also seemed to have deteriorated. Landscape structure is considered to be influenced by these socio-economic changes. For example, the frequency of *Miscanthus sinensis* grassland, which includes *Arundinario chino-Miscanthetum sinensis*, markedly increased, except in the mountainous area (Figs. 2–6). In the Kanto district the coverage of *Arundinaria chino* increased due to the abandonment of grassland management (Miyawaki *et al.*, 1977; Miyawaki, 1986). The increase in frequency of *Arundinario chino-Miscanthetum sinensis* seems to have occurred by the spread of *Pleioblastus chino* due to the abandonment of grassland management. In the southern part of the Boso Peninsula, the relative dominance of grassland decreased, while that of forest increased. This change was probably also caused by the abandonment of management of grassland. In the farm villages some areas of grassland have changed to forests through the process of succession due to the abandonment of traditional land use (Someya *et al.*, 1989, Kamada and Somiya, 1995, Kamada and Nakagoshi, 1997).

In the present study, we tried to clarify the changes in landscape structure over a century and to compare the landscape structure among the five areas on the basis of old maps and a map of the actual vegetation. Land-cover categorizations of these two maps were different and there was a possibility that small patches were not represented on the maps. However, we were able to reveal the basic points of regional differences in landscape structure and their change. In the dissected diluvial plateau area, which is located near the center of Chiba City, forest decreased drastically, while residential area increased due to human intervention. In the coastal and lakeshore plains, which were located on the northern part of the Boso Peninsula, paddy fields predominated. In the hilly and mountainous areas, which were located in the southern part of the Boso Peninsula, vegetational succession progressed due to the abandonment of traditional land management.

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房総半島の5地域における1880年代と1980年代の景観構造の比較

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1880年代(明治期)に作成された迅速図原図および1980年代に発行された現存植生図をもとに，房総半島の5つの地域における1880年代と1980年代の景観構造の比較を行った．1880年代には，房総半島北部に位置する八日市場（海岸平野地域），小林（印旛沼周辺平野地域）および千葉東部（東京湾岸平野と下総台地を含む開析台地地域）では水田およびマツ林の相対優占度が高かった．一方南部に位置する海士有木（丘陵地域）ではマツ林および草地が優占し，同じく大多喜（山間地域）では落葉広葉樹林，マツ林および草地が優占しているのが特徴的であった．房総半島南部に位置するこれら2つの地域は，森林，低木や草地か

らなるモザイク状の景観構造が特徴的であった．1880年代において，景観構造の地域差がみられた．海岸平野地域および印旛沼周辺平野地域では，約100年間にわたって水田が卓越していたが，マツ林の相対優占度は減少し，常緑および落葉広葉樹林の増加もみられた．開析台地地域では都市化にともない居住地の相対優占度が急増した．丘陵地域ではコナラなどの落葉広葉樹林，およびスダジイなどの常緑広葉樹林が優占植生になるようになった．山間地域では落葉広葉樹林の相対優占度が増加し，草地的植生およびマツ林の相対優占度が激減していた．これは耕作地，草地および森林の管理を放棄したことによって植生の遷移が進んだためと考えられる．