3. Floristic composition in the Yatsuda agro-ecosystem in three different geomorphic conditions (inter- and intra-landscape scale analysis)

3.1. Description of three study areas

Corresponding to the analysis in Chapter 2, three study sites were selected to cover upland (Site A), low-relief hills (Site B), and high-relief hills and low-relief mountains (Site C).

All Yatsuda landscapes were looked around in each calculation unit of given approximately 5 km around areas. Thereafter, a small catchment of about 1 km around where traditional method of geomorphic condition is typical to each type of Yatsuda landscape and where rice culture is still carried out is selected to the study sites. Table 3.1-1 shows a general description of the study sites. Figure 3.1-1 illustrates the present land use of the three study sites.

Table 3.1-1 General description of study sites.

	Site A	Site B	Site C
Elevation on valley floors	c.a. 20 m	c.a. 80 m	c.a. 120 m
Location of geomorphic condition	Shimosa Upland	Tama Hills	Yamizo Mountains
Climate condition			
Annual mean temperature	15.4 °C	14.1 °C	12.6 °C
Annual precipitation	c.a. 1,290 mm	c.a. 1,570 mm	c.a. 1,320 mm
Population density (/km^2)	c.a. 3,300	c.a. 5,200	c.a. 100
	(Chiba City)	(Machida City)	(Motegi Town)
Gradient of valley floor	1.2	2.9	5.0
Relief energy	9.0	31.5	42.5

Gradient of valley floors and relief energy were recalculated using the results in Chapter 2.

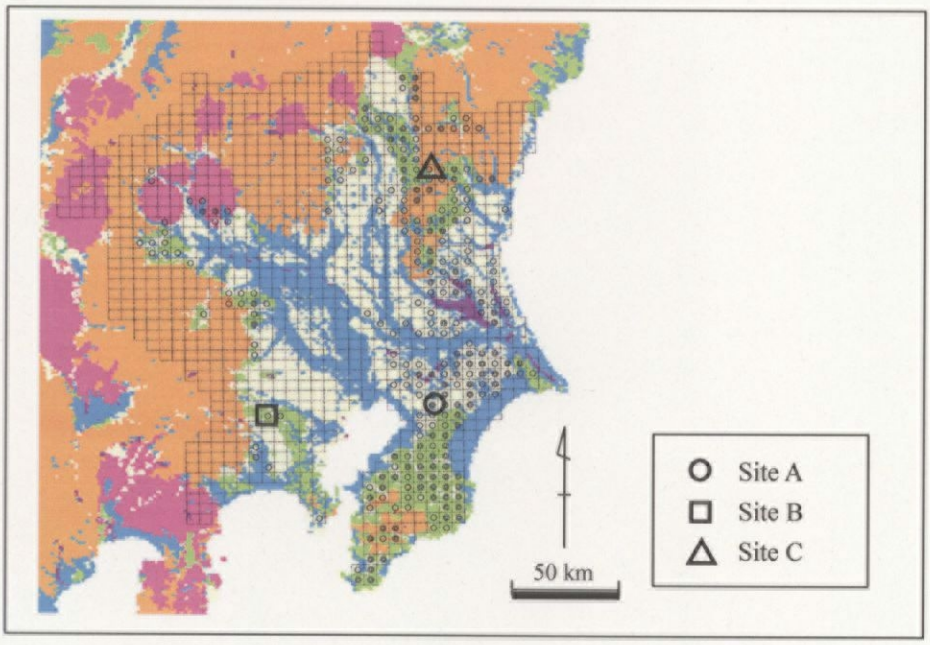

Figure 3.1-1 Location of three study sites.

Legends are similar to Figure 2.3-2

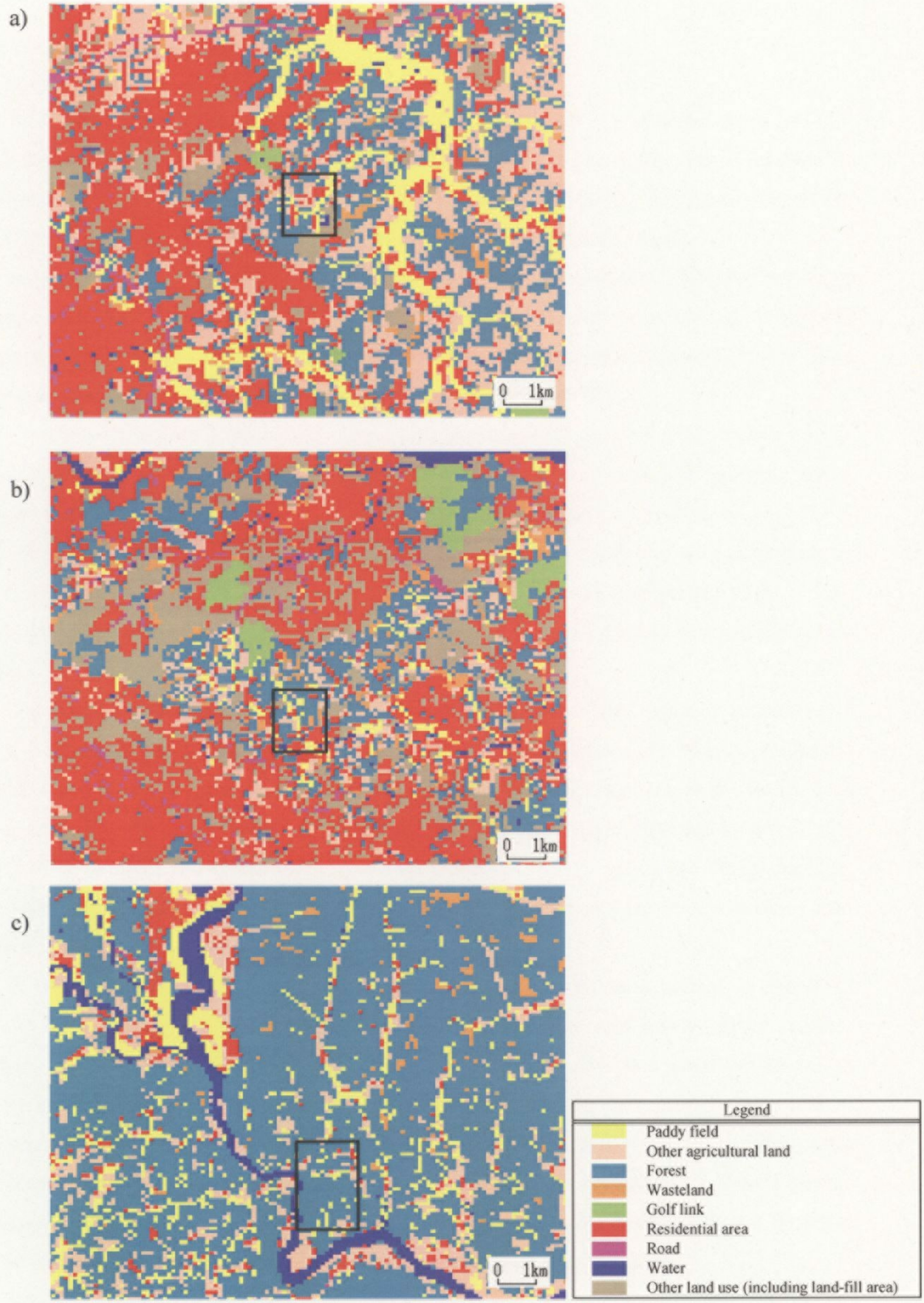

Figure 3.1-2 Land uses around the three study sites (a: Site A, b: Site B, c: Site C). (Squares in a), b) and c) correspond to the range of Figures 3.1-3, 3.1-4 and 3.1-5)

3.1.1. Site A

Site A is located in the Shimosa Upland, at a latitude 35° 38' N and longitude of 140° 12' E, a suburban area of Chiba City, southern Kanto region. The study site is located in zero-ordered valley floors according to 1: 25,000 geographical maps, but actually there are small channels in the valley floor, which discharge into the Inbanuma Marsh.

According to the analysis of Chapter 2, the gradient of valley floors at Site A is 1.2 % on average, which is similar to the average values in Yatsuda landscapes located in uplands (Type A). Relief energy is 9.0 m on average, which is lower than the average values in Type A, but is reasonable considering its standard deviation (14.7 ± 6.0).

Climatological data (1971-2003) from a nearby meteorological station at Chiba is as follows: annual mean temperature is 15.4 °C ranging from a minimum monthly mean temperature of 5.4 °C in January to a maximum monthly mean temperature of 26.4 °C in August. The mean annual precipitation is 1294 mm. WI (warmth index of Kira's), defined as the annual sum of monthly mean temperature above 5 °C excluding negative values is 125, while CI (cool index of Kira's; defined as the annual sum of monthly mean temperature below 5 °C excluding positive values) is 0.

The surface soil is covered with Andic soils. The Joso Clay layer forms an impermeable layer. Sediments underlying the surface consist of unconsolidated Late Pleistocene period deposits, commonly known as the Narita Group (Sugihara, 1970; Sugihara, *et al.*, 1978). This group comprises several formations consisting of fluvial gravels, tidal flats and inner bay silts, and littoral to upper netric sand, but the major component of the group are sandy deposits. The layer underlying the study area is a sandy deposit. The Shimosa Group is a cycle of land sediment and marine sediment of the Quarternary.

A detailed-scale geomorphic map of the study area and its surroundings is shown in Figure 3.1-3. There are two types of terraces; higher terrace and lower terrace. Higher terraces are widespread 30 m a.s.l., whereas lower terraces are observed partially within 3 m above the level of valley floors. The lower terrace chosen in this study is assumed to correspond to the Shimosa lower terrace (Chiba City, 1983). Terrace scarps have either gentle or steep slopes. This might be due to the predominance of deposition in Jomon marine transgression (Yagi & Yoshimura, 2000). The depth of valley floors is about 10 m as shown in the results of the previous chapter. Steep terrace scarp is less than 5 m high.

Upland terraces are used for either coniferous plantation or upland fields. The terrace scarp is covered by deciduous coppice woodland. Paddy fields are not intensively but moderately modernized. Paddy lots are joined, but drainage is still not sufficient (Chiba city, 2003). Paddy fields were consolidated to larger parcels in former part of the 1990s, but ditches and footpaths remained unpaved.

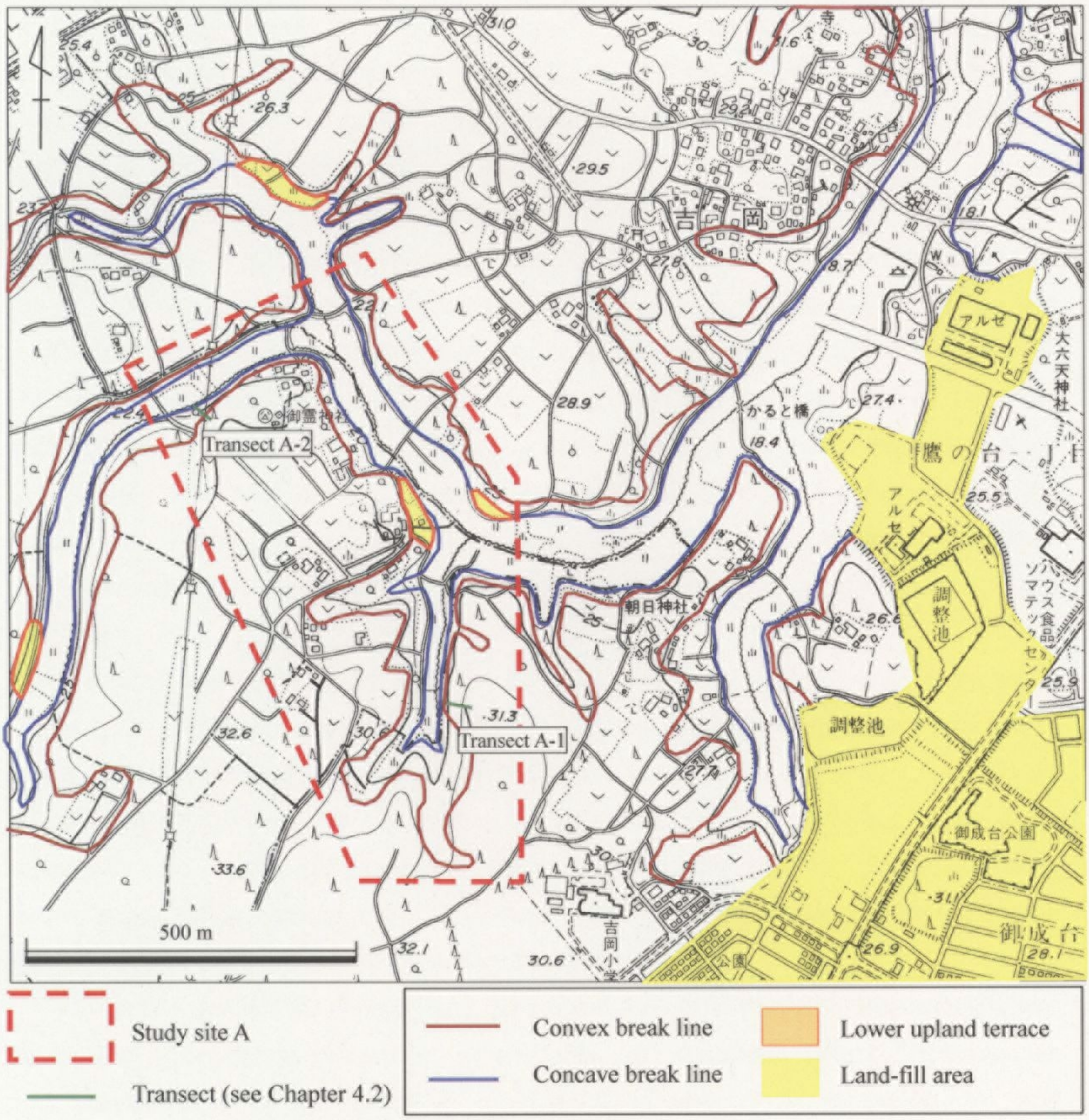

Figure 3.1-3 Detailed-scale land-form classification is Site A.

3.1.2. Site B

Site B located in the Tama Hills, at latitude 35°35′N and longitude 139°25′E, which is a suburban area of Machida City, Tokyo metropolis. The study site is located in a headwater area of the Tsurumi River. Although residential areas are wide-spread in the area, the study area still remains rural landscape.

According to the analysis presented in Chapter 2, the gradient of valley floors and relief energy at Site B are 2.9 % and 31.5 m on average, respectively, which is similar to the average values in Yatsuda landscapes located in low-relief hills (Type B).

Climatological data (1979-2000) from a nearby meteorological station at Hachioji is as follows: the annual mean temperature is 14.1 °C, ranging from a minimum monthly mean temperature of 3.1 °C in January to a maximum monthly mean temperature of 25.8 °C in August. The mean annual precipitation is 1570 mm. WI is 113, while CI is -3.

The bedrock of the Tama Hills consists of semi- or unconsolidated sedimentary rocks from the Pliocene to Middle Pleistocene period, commonly known as the Kazusa Group. This group comprises several formations consisting of fluvial gravels, tidal flats and inner bay silts, and littoral to upper neritic sand from the lower to the upper part of the group (Takano, 1994). The layer underlying the lower half of the study area is a mudstone, which forms an impermeable layer at the study site, while that underlying the upper half is sandstone, which is an aquifer. Most soils in the area contain tephra; the soil type of the paddy fields on the valley floors is Andic Gleysols. According to the 1:50,000 surface soil map, valley floors were composed of lowland soils, while the terrace was composed of Andic soils (Tokyo Metropolis, 1995).

A detailed-scale geomorphic map of the study area and its surroundings is shown in Figure 3.1-4. Hill ridges are about 30 m higher than the adjacent valley floor. Two types of ridges can be identified. Higher hill-top gentle slope was about 110-120 m a.s.l., while lower hill-top gentle slope was about 100m a.s.l., located around the higher hill-top gentle slope, adjacent to valley floors. Hill-slopes between the lower hill-top slope and valley floors were mostly steep. Valley bottoms had 1-3 % slope. The higher gentle slopes were located on gravels, whereas the lower gentle slope located above sandy stones.

Hill ridges are used for coppice woodland. Head hollow, defined by Tamura (1981) was the location of coniferous plantation. Upland fields, once commonly seen in hill ridges, are now abandoned to be succeeded by woodland (Ichikawa, *et al.*, in press). No land modernization is performed in the primary valleys including the study site. The site lies inside the 33-ha Zushi-Onoji Historic Environmental Conservation Area, which was proclaimed a

Greenery Designated Conservation Area by the Tokyo Metropolis in 1978.

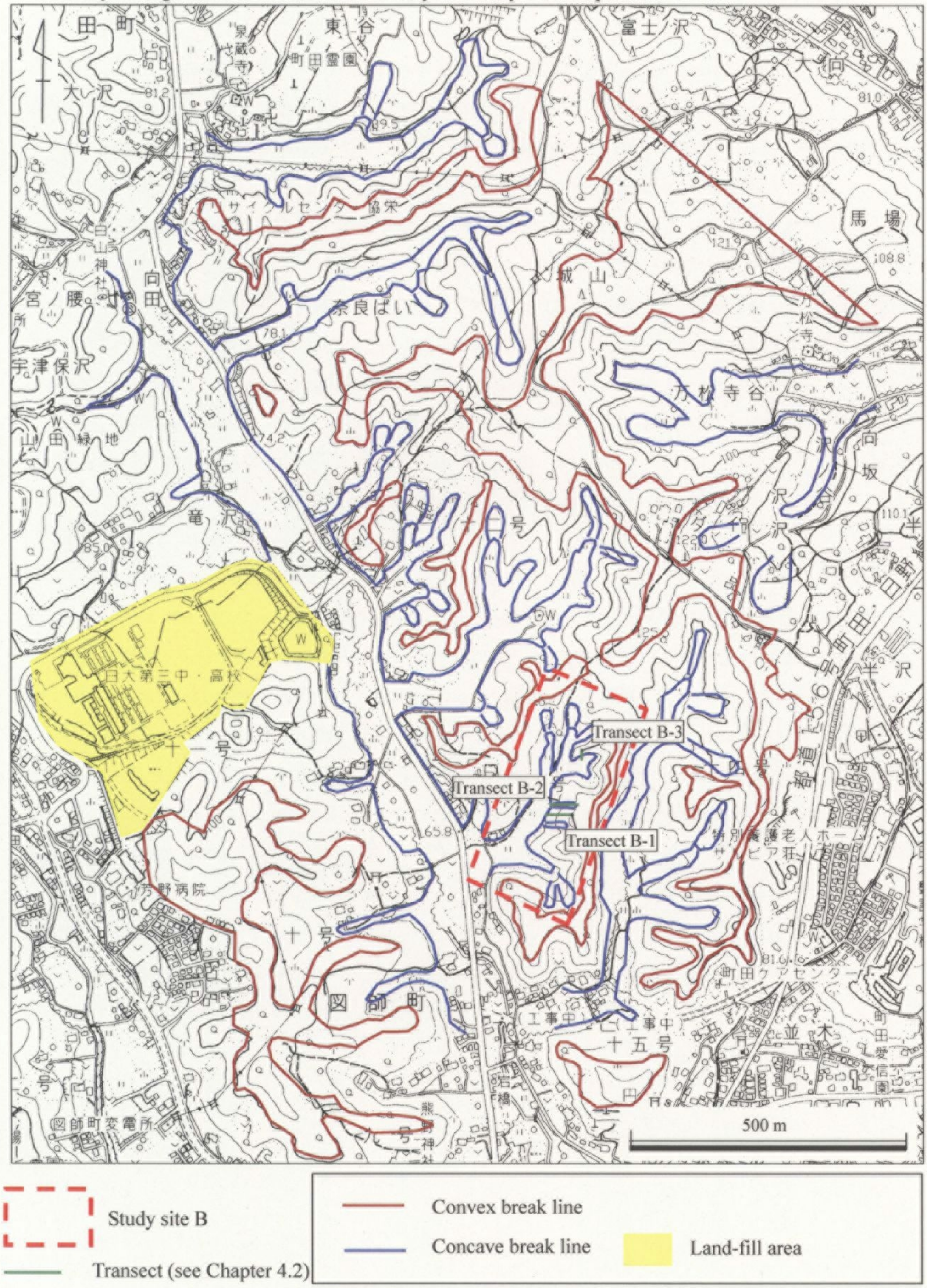

Figure 3.1-4 Detailed-scale land-form classification in Site B.

3.1.3. Site C

Site C is located in the Yamizo Mountains, at latitude 35°35'N and longitude 140° 12'E, which is a rural area in Motegi town, Tochigi Prefecture.

According to the analysis of Chapter 2, the gradient of valley floors and relief energy in Site B are 5.0 % and 42.5 m on average, respectively, which is similar to the average values in Yatsuda landscapes located in both high-relief hills and low-relief mountains (Type C).

Climatological data (1979-2000) from a nearby meteorological station at Karasuyama is as follows: the annual mean temperature is 12.6 °C, ranging from a minimum monthly mean temperature of 1.7 °C in January to a maximum monthly mean temperature of 24.3 °C in August. The mean annual precipitation is 1320 mm. WI is 98, while CI is -7.

The Yamizo Mountains consist of four major mountain blocks; Yamizo Mountain, Torinoko Mountain, Keisoku Mountain and Tsukuba Mountain, listed from north to south (Kaizuka, *et al.*, 2000; Hoshi & Takahashi, 1996). The study area is located in the fringe area of Trinoko Mountain.

The bedrock consists of tuff and andesite from the Miocene. The former rock forms an aquifer, while the latter is an impermeable layer (Motegi town, 1995). According to the 1: 50,000 surface soil map, valley floors are mostly composed of Gleysols while mountain slopes are covered by brown forest soil (Tochigi Prefecture, 1988).

A detailed-scale geomorphic map of the study area and its surroundings is shown in Figure 3.1-5. The highest gentle slope was 220 m a.s.l., while the lower one was 180 m a.s.l. The highest gentle slope was covered by tuff, while the lower gentle slope was covered by andesite. Valley bottoms had a 4-10 % slope. Paddy fields are located not only on gentle slopes but also on relatively steep slopes. All the water for rice cultivation is supplied by spring water.

Ridges are used mostly for coppice woodland. No land modernization is performed in the primary valleys including the study site.

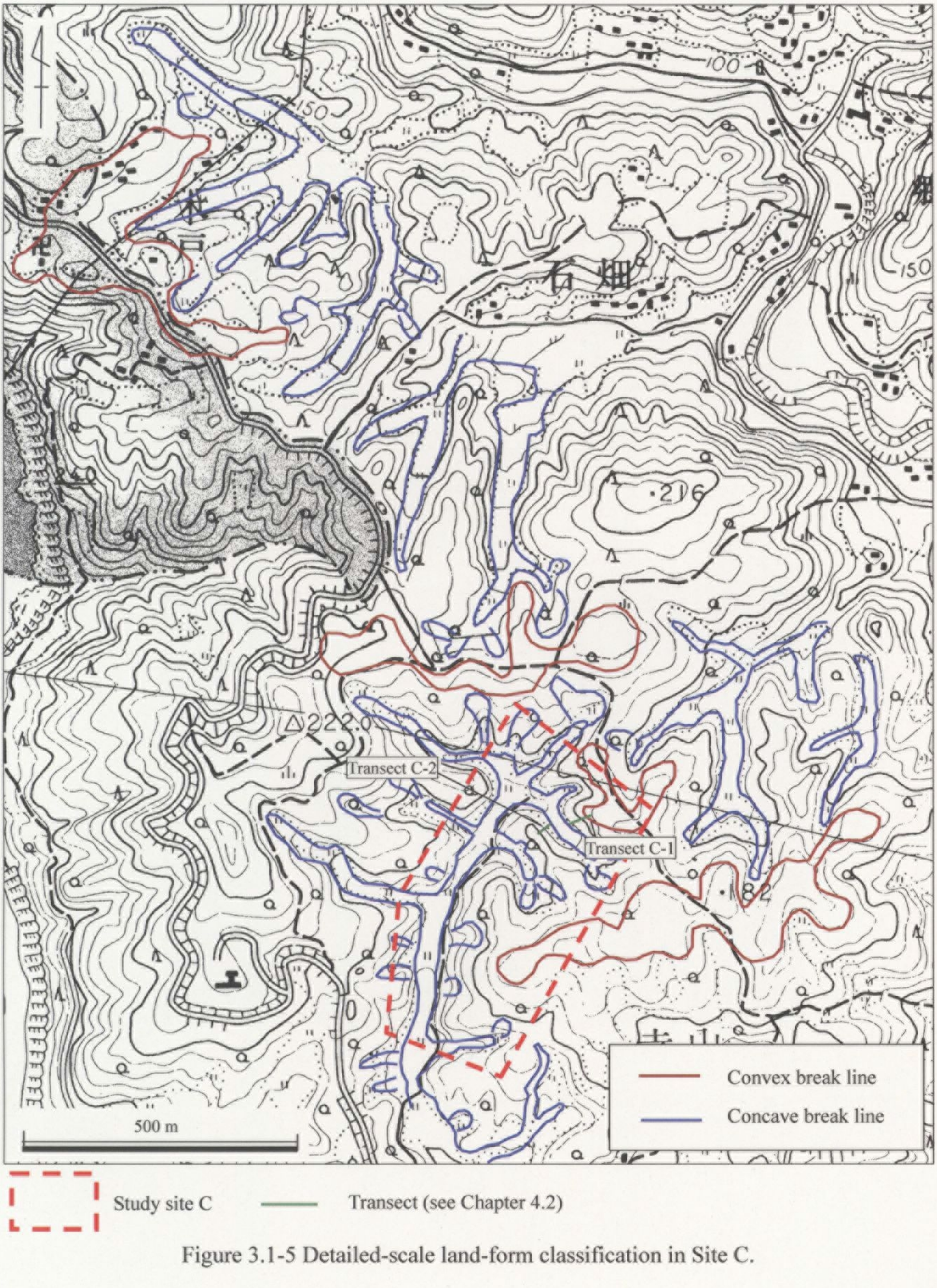

Figure 3.1-5 Detailed-scale land-form classification in Site C.

Figure 3.1-6 Yatsuda landscape in Site A.

Figure 3.1-7 Yatsuda landscape in Site B.

Figure 3.1-8 Yatsuda landscape in Site C.

3.2. Influence of climatic condition

Floristic composition was affected by various factors. Since the Kanto region extends widely both horizontally and vertically, climatic conditions may affect the floristic composition in Yatsuda agro-ecosystems. There is a major classification of climatic condition according to types of climatic forests in Japan. According to this, the southern Kanto region, especially the Kanto plain, belongs to a warm temperate zone, corresponding to the floristic class Camellietea japonicae in plant sociology. A cool temperate zone, corresponding to Fagetea crenatae, is located in the northern and the mountainous areas of the Kanto region. The boundary altitude between the two zones is 600 to 800 m a.s.l. in the Tanzawa Mountains, about 450 m in the Kanto Mountains, and 350 m in the Yamizo Mountains.

Besides, between the two zones, there is a transient zone, called a semi-temperate zone. It is broadly included in the warm-temperate zone, where evergreen coniferous trees were replaced by deciduous broad-leaved trees. WI is an approximate indicator of annual potential evapotranspiration and net radiation, which are major factors affecting plant productivity. The boundary WI between the warm-temperate zone and semi-temperate zone is 117, whereas that between the semi-temperate zone and cool-temperate zone is 74 (Nogami, 1994). According to this, the southern Kanto region, central Kanto region and northern Kanto region are warm-temperate, semi-temperate and cool-temperate zones respectively.

In the case of semi-natural vegetations, however, a different trend was observed. They were affected less by climatic conditions. For instance, paddy weed communities in Honshu Island are regarded as one association, Sagittario – Monochorietum (Miyawaki, 1986). Even in the Tohoku region, adjacent to and north of the Kanto region, almost all characteristic species in the association were observed, except for *Sagittaria pygmaea* and *Dopatrium junceum* (Miyawaki, 1986). Weed communities in levees, Lobelio – Ixeridetum japonicae, are also similar in the Kanto region and the Tohoku region. The only exception is *Potentilla centigrana* (Miyawaki, 1986). Semi-natural grassland is characterized by Miscanthetea sinensis, which extends throughout the southern Tohoku region with similar characteristic species. Verges of paddy fields to adjacent forest were the habitats of shrubby or creeping plants named Clematidetum terniflorae, which is also common in the southern Tohoku region. These indicate that although floristic composition at the forest floor was carefully analyzed, major plant communities in the Yatsuda agro-ecosystem associated with agricultural practices were likely to be similar due to climatic condition.

3.3. Materials and methods

Data collection

At each study site, the floristic composition of three landscape elements (agricultural management units), i.e. paddy fields, levees and verge meadows were surveyed. In the three landscape elements, quadrats of either 1 m^2 or 4 m^2 were selected with similar interval in each study site in order to roughly clarify the whole flora of given catchment.

In levees and verge meadows, approximately 40 permanent quadrats of 1 m^2 were selected. These quadrats are scattered in each study area. All species occurring throughout the year were recorded more than twice in a year.

Within paddy fields, agricultural practices like soil tillage and hand weeding make individual species low in density and it is not realistic to set permanent quadrats, hence quadrats of 2 m around were surveyed in different places inside the same parcel.

Analysis

Species were categorized into life-forms (dormancy form, disseminule form and plant height, Numata and Yoshizawa, 1979; Chibaken-shiryou-kenkyuzaidan, 2003) and native vs. exotic species. Besides, all species were divided according to their distribution. The species recorded across several quadrats in different habitat types are defined as common species, and the species not recorded in other habitat types are defined as unique species.

To clarify the traits of appeared species, all recorded species were categorized into five potential habitat types; upland fields or roadside species (UR species), species favoured in wet conditions (W species), grassland species (G species), forest margin species (FM species) and forest floor species (FF species). W species were selected in a broader sense than by common definition, to detect wet condition sensitively.

The shapes of levees are different at the different study sites. Paddy fields in upland fields (Site A) have a shorter slope (less than 50 cm), whereas those in high-relief hills tend to have a longer slope (more than 1 m on average). A preliminary investigation indicates that in Site A, a relative abundance of species was observed on flat footpaths, whereas at Site C, slopes were more abundant in species than footpaths. Most species in an area which is less abundant in species can be observed on the slope of the levee. We therefore investigated either footpaths or slopes of levees in each studied levee.

The floristic data was compared according to two aspects, the intra-landscape scale and the inter-landscape scale. At the intra-landscape scale, three agricultural habitat types were compared, while at the inter-landscape scale, each management unit was compared at the three study sites.

To clarify the general differences among landscape elements, life histories of plants species (i.e. annual herbs, perennial herbs and woody species) were calculated based on the dormancy form. At the intra-landscape scale, the occurring species were categorized into unique species and common species by species distribution. The species recorded in more than one agricultural management unit are defined as common species and the species not recorded in other management units are defined as unique species. At the inter-landscape scale, percentage similarities in each landscape element, which were based on the frequencies of occurrence of each species, were calculated.

3.4. Results

3.4.1. Difference of environmental conditions in each study site

Differences of slope length of levees and verge meadows (the length of mown slope area) are illustrated in Figure 3.4-1 and Figure 3.4-2. Corresponding to the landscape classification in Chapter 2, in terms of length of levee, Site A has the shortest, followed by Site B and then Site C. At Site A the length was mostly less than 50 cm, and in Site B the length was mostly from 50 cm to 1 m, while in Site C levees with more than 1 m length were common in number.

In terms of the length of verge meadows, Site A has the shortest, followed by Site B and then Site C. At Site A more than half of verge meadows have slopes with less than 2.0 m length, whereas in Site C more than half of verge meadows have slopes with more than 4.0 m length.

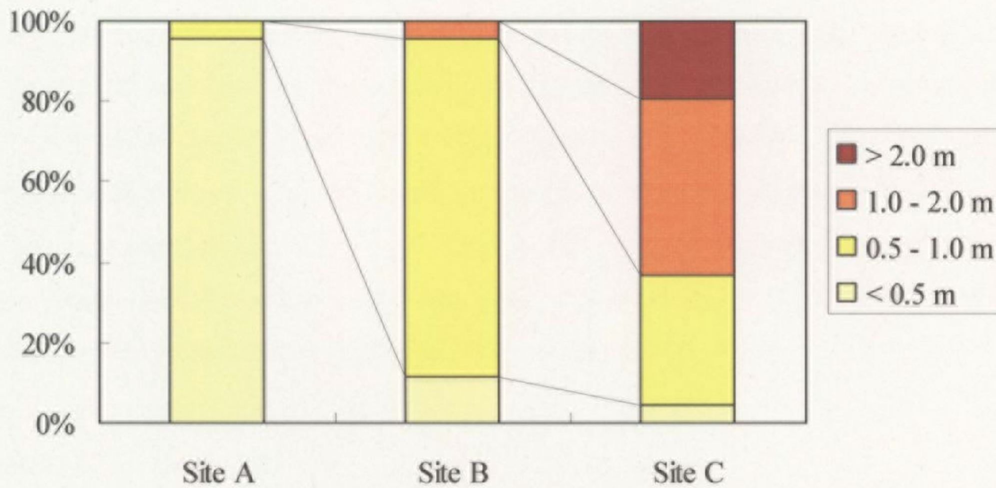

Figure 3.4-1 Slope length of levees in three study sites.

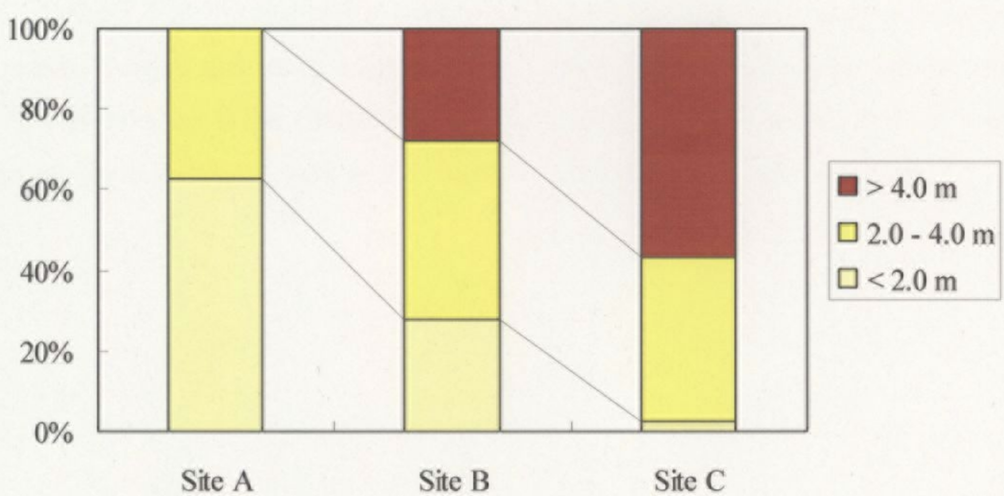

Figure 3.4-2 Length of verge meadows in three study sites.