Biocultural diversity and functional integrity of Japan's rural landscape

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Biokulturelle Diversität und funktionale Integrität der Kulturlandschaft Japans

1 Introduction

Interactions between humans and nature have become a key issue in preserving biodiversity and sustaining human life. During the initial development of the science of ecology, ecologists considered human activities to be destructive agents that damaged nature, particularly in terms of the conservation of biodiversity, and the preservation of nature was seen as the setting aside of natural environments to protect them from human activities.

However, natural environments that have been modified by human activities such as agriculture and forestry have also been the subjects of ecological research, and this "semi-natural" vegetation was defined and studied as early as the

Zusammenfassung

Alle wichtigen Bestandteile der japanischen Kulturlandschaft, Satoyama, werden gemeinsam dazu genutzt die Lebensgrundlage für die Menschen zu schaffen und gleichzeitig eine große Biodiversität in unterschiedlichen Habitattypen zu erhalten. Naturnahe und halbnatürliche Wälder und Grünland im Nahbereich von Tokyo stellen Lebensräume für Reliktarten von vormals extensiv genutzten Graslandschaften dar inklusive der Flächen, die als Pferdeweiden genutzt wurden. Mähwiesen werfen nicht nur Viehfutter und Gründünger ab, sondern öffnen das Land für den Ackerbau, indem sie die Beschattung durch angrenzende Wälder reduzieren und beherbergen außerdem Reliktarten. Daher ist traditionell bewirtschaftete Satoyama-Kulturlandschaft eine funktionale Einheit eines nachhaltigen Systems, in dem sogar auch nur der teilweise Verlust von Wäldern oder Grünland oder die Änderung der Bewirtschaftungsweise (z. B. Ersatz der Rinder und Pferde durch Maschinen) zur Zerstörung seltener Lebensräumen für eine Vielzahl von Arten und damit zu erheblichem Verlust von Reliktarten führen. Die dritte nationale Biodiversitätsstrategie Japans zeigt, dass fast die Hälfte der gefährdeten Arten einst in den Kulturlandschaften häufig vorgekommen ist. Hauptgrund für den Artenschwund ist der Habitatsverlust durch Nutzungsänderung in Verbindung mit sozio-ökonomischen Veränderungen im suburbanen Bereich.

Schlagworte: Lebensraumvielfalt, traditionelle Bewirtschaftung, Grünland Relikte, Satoyama.

Summary

All major components of the Japanese traditional rural landscape, Satoyama, are used to sustain livelihoods and to keep rich biodiversity in various habitat types. Semi-natural forests and grasslands maintained through traditional agricultural practices in suburban Tokyo are habitats for relict species from previous, extensive grasslands, including the land used for horse grazing. Mown grasslands not only provide fodder and green manure, but also open margins for arable land, reducing its shading by neighbouring forests and harbouring relict species. Traditionally maintained s*atoyama* thus represents a functionally integrated sustainable system in which even partial loss of forests and grasslands, or modification of agricultural activities (e.g., replacing cattle and horses with machines), may destroy marginal habitats for diverse species and lead to a considerable loss of endangered relict species. The third National Biodiversity Strategy of Japan shows that nearly half of the endangered species were once commonly found in rural landscapes. Major causes of the species loss are habitat loss through the land use changes related to socio-economic changes in the suburban area.

Key words: habitat diversity, traditional management, grassland relics, *satoyama.*

1920s (e.g., TANSLEY, 1923). Nowadays, even human-modified parts of nature have become the subjects of study, as they represent an indispensable heritage capable of supporting human life; such semi-natural ecosystems are now being re-evaluated in terms of both their aesthetic effects and their importance for preserving biodiversity (HOLZNER, 2006, 2007; MCDONNELL and PICKETT, 1993; PIMENTEL et al., 1992). The traditional landscape of Japan, and particularly the rural agricultural landscape, is referred to as *satoyama* (*sato* = village + *yama* = mountain or forest) (cf. TAKEUCHI et al., 2003), a name that describes an integrated landscape modified by humans to provide sustenance as a result of long-term activities such as agriculture, forestry, and even hunting and gathering. Some of the biota produced by the *satoyama* biodiversity system still can be found in semi-natural forests and grasslands. These special habitats modified by human activities have persisted throughout the long history of the human-nature interactions in Japan. Therefore, conserving biodiversity in *satoyama* landscapes is inextricably linked to conserving the human activities such as traditional agriculture and forestry that sustain these landscapes. This paper examines the small-scale phenomena that surround us in an attempt to understand the mechanisms that generated the *satoyama* biodiversity patterns and to describe appropriate measures for conservation of this unique landscape and its biota.

The Third National Biodiversity Strategy of Japan (MINISTRY OF THE ENVIRONMENT, 2007) notes that nearly half of the endangered plant species can be found in the rural landscape. The decreasing level of human activity in the human-modified semi-natural vegetation of the *satoyama* has increased the risk of extinction of endangered, relict species through secondary succession.

This study was conducted mainly in Chiba and Ibaraki prefectures, in the eastern to northeastern suburbs of the mega-city of Tokyo. This area is especially interesting for understanding the patterns of biocultural diversity in the rural landscape and the mechanisms that generated these patterns, particularly from a historical perspective. Since 17th century, when Tokyo was founded as Edo, Japan's feudal capital, it has become one of the biggest cities in the world; therefore, the surrounding areas have experienced strong impacts from human activity. After the Meiji restoration (1868), Edo changed into Tokyo, Japan's capital during the age of democracy, but until the mid-20th century Japan's militarism strongly affected the biodiversity of this area, particularly in Chiba Prefecture, as will be discussed later in this paper.

Our hypotheses in this study are: (1) traditional land use created semi-natural habitats rich in biodiversity, (2) traditional rural landscape is constituted of all the elements which support functional sustainability through the interrelationships among all the elements, (3) agricultural intensification destroy the interrelationships among elements through mechanization or use of chemicals and causes the loss of semi-natural habitats, (4) New strategies of sustainable land management are needed to be developed to conserve relict species of semi-natural vegetation.

2 Biodiversity patterns in the rural landscape of Japan from cultural and historical perspectives: an example from the Tokyo suburbs

Biodiversity in a rural landscape depends on the land use types and their spatial configurations, since both determine the available habitat types for plant species. For example, the borders of fields are recognised as refugia for grassland species, and mown field margins are considered important conservation areas in Europe (BOATMAN, 1984, DE CAUWER et al., 2005). BENTON et al. (2003) emphasized that the biodiversity decline in farmland results from a loss of both spatial and temporal ecological heterogeneity and has been a general consequence of agricultural intensification in Europe and North America. The land use types and important habitats for rare and endangered species are related to not only the agricultural farming system but also to the general framework in which agriculture occurs, including socioeconomic activities, because this context affects agriculture, which in turn often drastically changes land use pattern. Land use changes usually reduces the habitat available for wildlife and reduces its likelihood of surviving such habitat loss. For example, ASKINS (2000) emphasized that the simplification of habitat types (e.g., loss of open habitat) as a result of ecological succession restricted the diversity of avifauna in north-eastern America.

For the last 150 years, Japan's rural areas have experienced large socioeconomic, agricultural, and forestry changes: (1) a transition from a feudal system to a democracy around the Meiji restoration (1868–1876), (2) the impacts of militarism during and after various war-time periods (from the beginning of the 20th century to ca. 1945–1955), and (3) the modern energy revolution (i.e., a shift from traditional fuels such as wood and charcoal towards fossil fuels) with the ensuing period of high economic growth (1955–1973).

Before the Meiji restoration, the land was divided into the

territories (*han*) of feudal lords (*daimyo*), and the land ownership system depended on the system imposed by each *daimyo.* In general, however, agricultural land was not owned by private farmers, but was instead owned by the feudal lord, communally by the village, or possibly by several big landowners, and farmers had only tenant rights (*kosaku*), except for the right to a home garden and land covering up to 500 m^2 around their houses.

Each farmer rented the land and cultivated it, but in many villages the system of tenanted land changed into a rotation system called *wari-chi*. The purpose of this rotation of the farmland was to balance out profits and losses of all farmers under the feudal system. For example, Narita village, near Nihonmatsu (Fukushima Prefecture), had a rotation at intervals of ca. 20 years (e.g., 1794, 1814, 1836, 1856). During a given *wari-chi* period, the farmers would gather to vote on the distribution of the farmland for the next 20 years (NIWA, 1989). This system continued until the Meiji restoration.

Under these systems, farmers understood that they did not own the arable land; instead, they rented it from someone else. Therefore, the lands surrounding the fields, including wastelands, unused lands, and even fallow fields, were considered to be commons and were the common property of the village. However, after the Meiji restoration, the land ownership system changed completely; villagers were forced to own the land privately by the modernization policy of the Meiji central government. This change greatly increased private ownership of the land (NIWA, 1989), and every piece of land, including even field margins, was owned by a particular farmer. This inevitably reduced the amount of unused wasteland and fallow land decrasing consequently the abundance of wildlife and plant habitats.

2.1 Kariage-ba (space resulting from the mowing of field margins)

One example of wasteland or field margins that could potentially enhance biodiversity in rural Japan is *kariage-ba*; this traditionally maintained space between agricultural fields and the surrounding forests was created by farmers (even in cases where they did not own the land) who traditionally had the right to cut the tall grasses, shrubs, and even trees that would otherwise shade their crops (NIWA, 1989). The cleared *kariage-ba* belt around fields is typically 1 to 3 m wide, but a well-maintained *kariage-ba* can nonetheless effectively protect arable fields from wild animals. Cut grasses and other residues from this management are used as green manure for the fields. In the form of sustainable agriculture that was practiced in the early 20th century, farmers harvested materials such as construction timber, wood for fuels and tool handles, and fertilizer materials from the surrounding forests.

KITAZAWA and OHSAWA (2002) have studied mown grasslands in field margins around the traditional paddy fields in Chiba, central Japan (Fig. 1). Mown grasslands in *kariage-ba* are dominated mainly by grassland species such as *Miscanthus sinensis* Anders., *Imperata cylindrica* Beauv., and *Pleioblastus chino* Makino, which can tolerate frequent mowing (two to four times a year). The mown *kariage-ba* habitat has a particularly rich flora compared with those of other types of grassland (abandoned grasslands, trampled grassland along roadside, weedy community in cultivated fields) because it sustains relict populations of rare grassland species, including *Adenophora triphylla* A.DC. var. *japonica* Hara, *Campanula punctata* Lam., and *Gentiana scabra* Bunge (Figure 1).

These rare species include geophytes with rhizomes that are similar to those of the dominant grassland species (*Miscanthus, Imperata* and *Pleioblastus*) mentioned above; therefore, they also tolerate frequent mowing (Table 1).

2.2 Maki (grazing pasture for horses)

In addition to the *kariage-ba* sites, extensive grazing pastures were created for horses by using the rich pool of grassland species in many parts of Japan during the Edo era. Along the eastern outskirts of Edo (Tokyo) there were wide areas of rangeland used to raise horses; this land is called "*maki*". *Kogane-maki*, one such *maki* in the northwestern part of Chiba prefecture, covered ca. 15 000 ha and was maintained for nearly 300 years from when it was established in about 1600 and when it was abandoned in about 1868 (EDUCATION COMMITTEE OF CHIBA PREFECTURE, 2006). *Kogane-maki* supported 500 to 1500 horses, but those horses were raised under nearly wild conditions; every year Edo government officials inspected, caught, and transferred certain number of the horses to Edo, but they also sold some of these horses to local farmers.

We can see the vast extent of this grazing grassland in old wood paintings (*ukiyoe)* and guide map created during the 17th to 19th centuries (e.g., Figure 2). Earthworks related to the *maki*, such as *noma-dote* (banks protecting arable lands from invasion by the wild horses) are still visible. In 2007, a *noma-dote* in *Nakano-maki*, in Kamagaya City, Chiba Prefec-

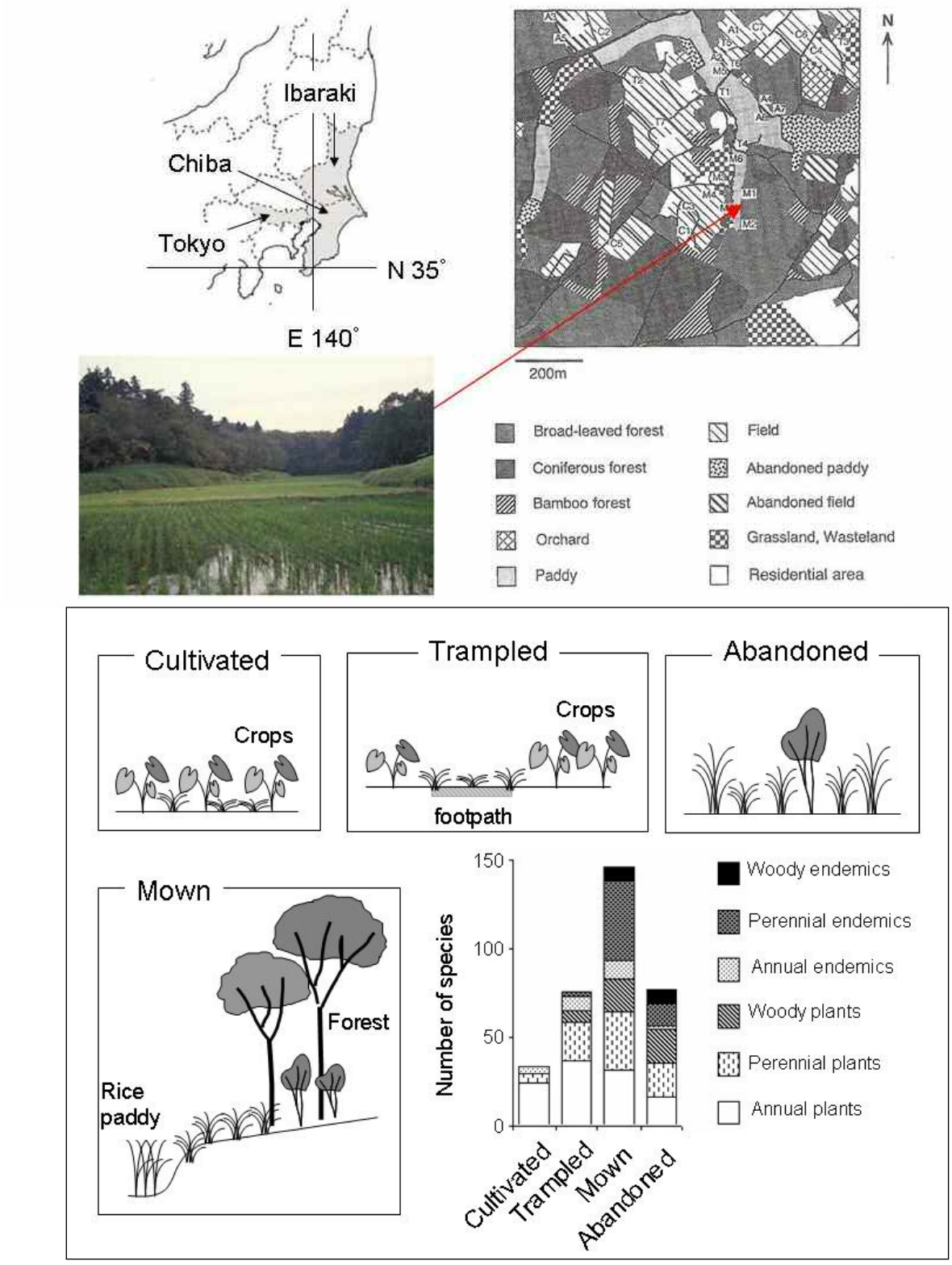

Figure 1: *Kariage-ba* (mowed grasslands around paddy fields) in the eastern part of Chiba city, and species richness in various semi-natural grassland types around the area (modified from KITAZAWA and OHSAWA, 2002)

Abbildung 1: *Kariage-ba* (Reisfelder umgebende Mähwiesen) im Osten der Stadt Chiba und Artenvielfalt unterschiedlicher halbnatürlicher Grünlandtypen in diesem Gebiet (verändert nach KITAZAWA and OHSAWA, 2002).

Table 1: Number of species in each functional type in the four main types of grassland habitat in the study area
Tabelle 1: Anzahl der Arten nach Funktionstyp für die vier Haupthabitattypen des Acker- und Grünlandes im Untersuchungsgebiet

Dormancy forms	Cultivated fields	Trampled road side	Mown grassland	Abandoned grassland
Common species				
Summer annual	12	16	18	9
Winter annual	12	21	14	8
Aquatic plant (annual)	–	1	–	–
Geophyte	3	5	11	6
Hemicryptophyte	1	12	14	7
Chamaephyte	2	4	6	5
Aquatic plant (perennial)	–	–	–	–
Nanophanerophyte	–	1	2	2
Microphanerophyte	–	2	10	10
Mesophanerophyte & Megaphanerophyte	–	4	8	8
Endemic species				
Summer annual	4	2	1	1
Winter annual	–	5	9	1
Aquatic plant (annual)	–	–	–	–
Geophyte	–	1	19	4
Hemicryptophyte	–	1	21	6
Chamaephyte	–	1	3	1
Aquatic plant (perennial)	–	–	1	1
Nanophanerophyte	–	–	5	1
Microphanerophyte	–	–	2	4
Mesophanerophyte & Megaphanerophyte	–	–	2	3

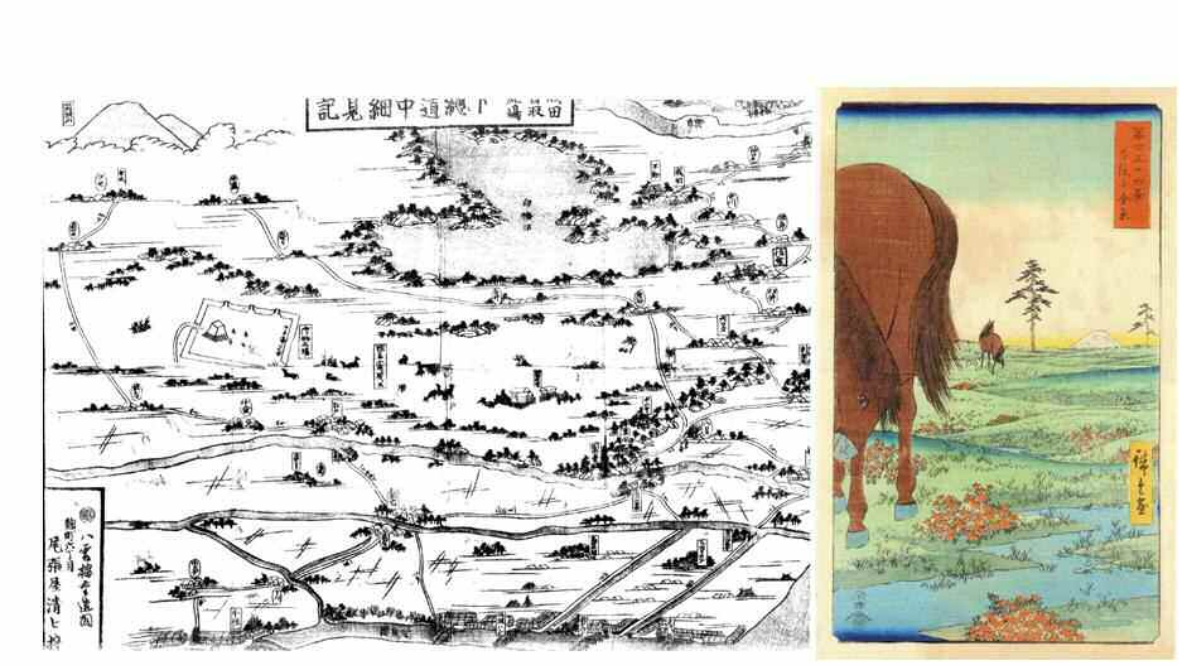

Figure 2: An example of maki depicted in a 17th century guide map of eastern Edo, and the landscape of Shimousa Koganehara, by Hiroshige Utagawa, from The 36 Scenes of Mount Fuji (1858). From the collection of Narita-san Reikoukan Museum and Chiba Prefectural Sekiyado-jo Museum
Abbildung 2: Ein Beispiel für Maki, abgebildet in einer Landkarte des 17. Jahrhunderts von Ost-Edo und der Landschaft von Shimousa Koganehara (Hiroshige Utagawa 1858: aus den 36 Szenerien des Mount Fuji). Aus der Kollektion des Narita-san Reikoukan Museums und dem Sekivado-jo Museum der Präfektur Chiba

ture, was inscribed into the register of National Historic Sites (EDUCATION COMMITTEE OF CHIBA PREFECTURE, 2006).

The *maki* were abandoned after the Meiji restoration in 1868, and after that the area was cultivated mainly by demobilized samurai and soldiers of the Tokugawa central government in Edo (Tokyo). However, the former *maki* area is not fertile land; therefore, farmers did not settle permanently in this area. Soon after the abandonment of their settlements, the vast *maki* lands were used for military training grounds during war-time, and some of the sites were maintained as grassland or open ground for military facilities, training grounds, or even airfields for air force. As a result, most of the land was not used intensively until the end of World War II.

Because of less intensive use but frequent disturbance in the area during several centuries, many grassland species survived in the area. Several intensive inventories of the local flora in this ex-*maki* area have revealed many rare grassland plants such as *Pulsatila cernua* Spreng., *Platycodon grandiflorum* A.DC., and *Sophora flavescens* Ait. that are surviving in small patches of open habitat that had been maintained as open grassland, such as in the *kariage-ba* mentioned above, along the margins of land used for various purposes (e.g., industrial estates, large market areas, extensive parks, rights-of-way for power lines), or even in the understorey of *Pinus densiflora* Sieb. et Zucc. forests and around their margins (CHIBA NATURAL HISTORY MUSEUM, 2003, TERANISHI, 2007).

Thus, the biodiversity of rural areas, particularly in terms of the grassland species that thrive in open habitats at the margins of human activities, is promoted by the favourable habitats that arise under less intensive land use.

The *Red Data Book* for Chiba Prefecture (NATURE CONSERVATION BUREAU, CHIBA PREFECTURE, 1999), where the whole area can be regarded as a *satoyama* landscape, revealed that most of the locally extinct (category X) plants and highly endangered plants (class A) were growing in wetlands and ecotonal habitats such as the areas between and on the margins of arable fields, between land and bodies of water such as rivers, ponds, lakes and the sea, and in secondary grasslands and forests (Figure 3). These areas reveal the importance of habitat that is marginal for human uses for the survival of wildlife and plants.

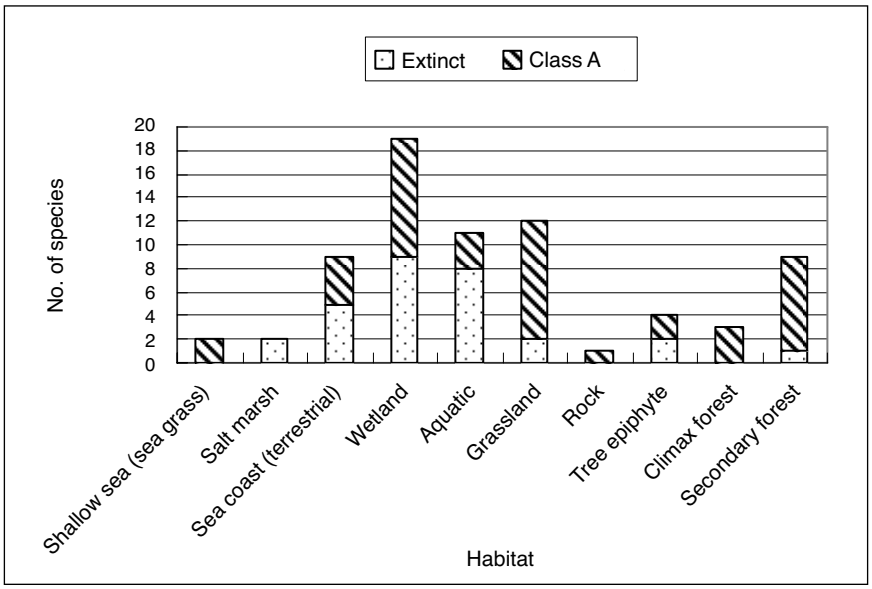

Figure 3: Species diversity in habitats formerly occupied by locally extinct plant species and currently occupied by endangered higher plants in Chiba Prefecture. (Data obtained from the Red Data Book of Chiba Prefecture – NATURE CONSERVATION BUREAU, CHIBA PREFECTURE, 1999)

Abbildung 3: Artenvielfalt in Habitaten, die früher aus jetzt ausgestorbenen Pflanzenarten bestanden und gegenwärtig von gefährdeten höheren Pflanzenarten eingenommen werden. (Daten aus der roten Liste der Präfektur Chiba – NATURE CONSERVATION BUREAU, CHIBA PREFECTURE, 1999)

3 Management of biodiversity and succession in rural areas

In addition to floristic diversity, the life-form composition of local vegetation is an important aspect of biodiversity. Agricultural practices involve the management of vegetation succession for a particular purpose, such as producing and utilizing a certain type of plant community for agricultural activities. For example, dry fields used for cultivating annual and perennial crops, grasslands used as pastures or for mowing to provide fodder, and wetlands used to grow rice. There are also various forms of woody vegetation, such as shrubland, orchards and forests of various types, including sacred forests.

In the context of ecological succession, human activities such as ploughing, mowing, grazing and cutting are the major factors that deflect the natural course of succession. Diverse habitat types in rural areas are thus created and maintained by farming practices (Figure 4). In recent years, however, rural villages have shown clear signs of an aging or rapidly declining population; therefore, in some areas, volunteer activities are becoming important ways to maintain traditional forms of agriculture and thus maintain these diverse habitat types. For these reasons, suburban rural areas are now supported by the activities of urban volunteers who try to continue the traditional rural management practices that produced semi-natural vegetation types such as grasslands, wetlands, and open semi-natural forests.

Recently, *The Third National Biodiversity Strategy of Japan* (MINISTRY OF THE ENVIRONMENT, 2007) emphasized the importance of agricultural and forestry practices for maintaining biodiversity in rural landscapes, and it noted that in the absence of these forms of management natural succession may proceed. Consequently, grasslands and open forests may not persist in most parts of Japan, as their sites will be eventually colonized by climax tree species.

Most of the endangered, relict plants in rural areas are elements of grassland vegetation that existed before human

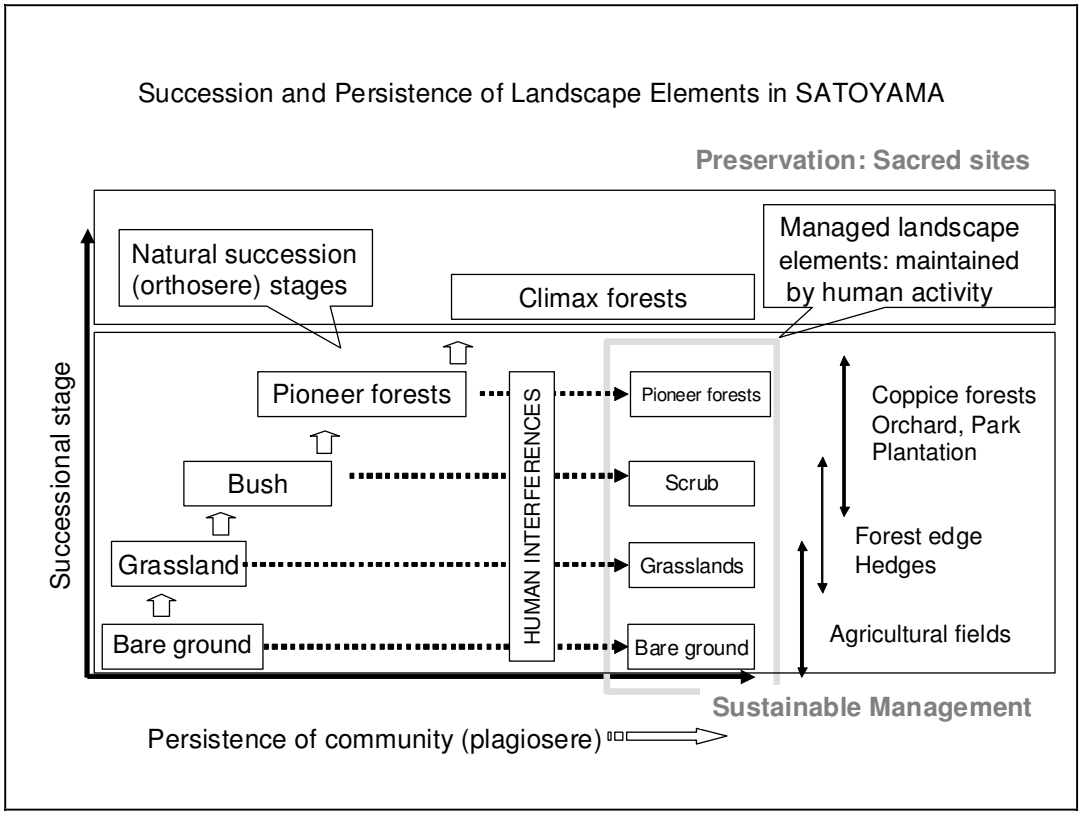

Figure 4: Landscape elements in a Japanese rural village and the associated successional stages. Natural successional stages are enclosed in boxes with broad arrow lines; plagioseral stages are in boxes indicated by arrows with dashed lines. Human management is shown at the right side of the figure

Abbildung 4: Landschaftselemente eines Japanischen Dorfes und die assoziierten Sukzessionsstadien. Natürliche Sukzessionsstadien sind in den Kästen mit breiten Pfeilen enthalten, Plagioseriale Stadien sind in den Kästen mit strichlierten Pfeilen. Menschliche Eingriffe (Management) sind an der rechten Seite der Abbildung dargestellt

management, and these species are often extinct outside these habitats or are nearing extinction because of the abandonment of management practices such as the regular mowing of roadside verges, use of grasslands as pastures, and coppicing of forests.

4 Functional integration of village landscapes in rural Japan

Many habitat types can be distinguished in the rural villages of Japan. They include forests (natural, semi-natural, human-made), grasslands (natural, semi-natural, human-made), fields (dry, paddy), residential areas, wastelands, road verges, and sacred sites such as shrines and temples, and all of these landscape elements have margins that often become important sites for preserving biodiversity. In traditional agricultural practices, each landscape element had its own function and interacted with several other landscape elements. For example, the productivity of agricultural fields and farmer's livelihood depended on the use of various materials collected from secondary forests, such as green manure, fuelwood, and materials for agricultural tools. TOKORO (1980) estimated that agricultural fields needed ca. ten times their area of forested land to meet these needs during the Edo period starting about 400 years ago in rural Japan. Hills and mountains around villages have also been used for *Miscanthus* grasslands.

FUJII (1981) conducted a detailed analysis of the functional interrelationships among landscape elements in a rural agricultural area ca. 50 km northeast of Tokyo during the energy revolution and subsequent period of high economic growth from 1955 to 1973 (Figure 5). Before this important transition (i.e., before 1965 of Figure 5), the landscape elements were strongly interrelated. However, after the energy revolution, farmers introduced agricultural machinery and trucks and abandoned the use of horses and cattle for ploughing and transportation. The loss of even this single agricultural component strongly affected other activities and drastically changed the local agriculture from closed to open system.

5 Urbanization and globalization: major impacts on rural biocultural diversity and conservation

The urban-to-rural continuum is a good reference gradient for evaluating human impacts on nature (MCDONNEL et al., 1997). However, most studies that have used this gradient have emphasized the effects of urbanization, urban expansion and sprawl, as well as the destructive nature of human interventions in natural ecosystems such as forests and grasslands. As we have shown in this paper, rural areas can be considered as unique entities with their own work-

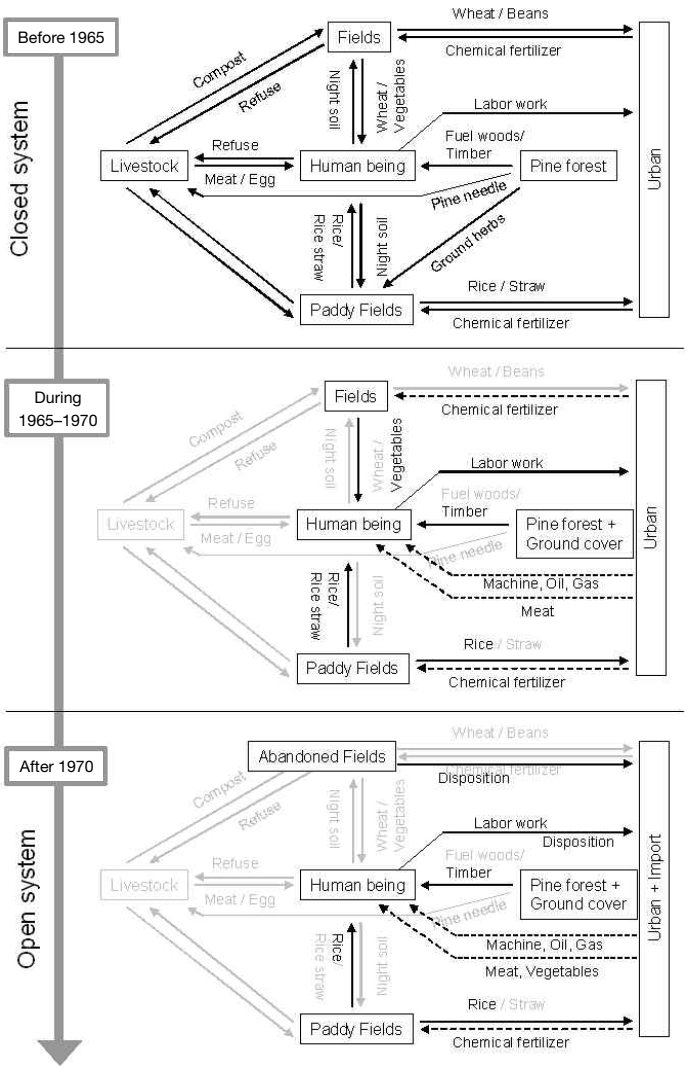

Figure 5: Components of a rural village and their interrelationships (modified from FUJII 1981). The integration of landscape elements through materials and energy cycles in southern Ibaraki Prefecture is drastically changed from a closed to an open system as it passes through three periods at around the time of the energy revolution and the period of high economic growth

Abbildung 5: Komponenten eines Dorfes und die Interaktionen zwischen den Komponenten (verändert nach FUJII, 1981). Die Integrierung von Landschaftselementen durch Stoff- und Energiekreisläufe in der südlichen Präfektur Ibaraka hat sich dramatisch verändert von einem geschlossenen zu einem offenen System

Table 2: Total number of plant species found in comparable grassland types in rural, suburban, and urban area around Chiba city, central Chiba. The value is a saturated total number of species found in belt transect. Traditional managed of rural area indicates Kariage-ba (see text), modern managed in suburban and urban areas indicate regularly mown grassland around the reservoir, road, and surroundings of residential area. These habitats are newly created after the modern energy revolution or the World War II

Tabelle 2: Gesamtzahl der Pflanzenarten vergleichbarer Grünlandtypen in ländlichen, stadtnahen und städtischen Gebieten nahe der Stadt Chiba, Zentralchiba. Angegeben sind die gesättigten Artenzahlen aus Probeflächen angeordnet in einem Transekt (belt transect)

	rural traditional managed	suburb modern managed	urban modern managed
Saturated area (m^2) of total number of species	69	55	44
Total	142	71	51
Native sp.	131	45	36
Alien sp.	11	26	15
Alien/Native ratio (%)	7,7	36,6	29,4
Raunkiaer's life-form type			
Th	14	23	12
Th(w) winter annual	18	16	10
G	27	5	7
H	33	18	13
Ch	12	5	3
HH	1	1	
Unspecified Perennial Herbs	5	1	
N	8		2
M	14	1	2
MM	10	1	2

ing mechanisms, including human impacts, and biological features such as biodiversity and adaptation of organisms inhabiting an area.

In addition to the uniqueness of the ecological habitats of rural landscapes, continuous human activities related to traditional agricultural and forestry practices provide another type of habitat that favours the survival of relict species, as we discussed in relation to the relict grassland species found in the *kariage-ba* areas of rural Japan. This relict biodiversity is thus another feature related to human activities in the rural landscape (OHSAWA, 2008). Table 2 illustrates species diversity and life-forms in rural traditionally managed ancient habitat of *kariage-ba* with high percentage of native species as compared to the modern newly established grasslands. In rural areas, the diverse habitat types created by human activities can provide habitat for a wide range of ecological types through various disturbance regimes such as regular ploughing, mowing, trimming, cutting or logging. This can preserve selectively certain life forms or ecological types such as Geophyte (G), Hemicryptophyte (H), and Chamaephyte (Ch) in mown grassland (*kariage-ba*).

There are strong modern trends towards urbanization and globalization, in which many traditional farmers are abandoning their farms and moving to big cities or in which traditional farming is being replaced by large-scale, intensive agriculture to support the export of high-value food products. Both trends are having serious adverse impacts on traditional ways of farming, and are endangering the continued existence of the *satoyama* landscape. This poses a serious risk to the rare, endangered, relict species that continue to survive only because of the continued existence of these habitats. To protect these species, preservation of the niche habitats and their proper management currently serving as refugia are urgently necessary.

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