

Effects of Ski Resort Management on Vegetation

KUBOTA, Hitomi

SHIMANO, Koji

Faculty of Science, Shinshu University

3-1-1 Asahi, Matsumoto City, 390-8621 Japan

shmano@shinshu-u.ac.jp

Tel & fax: +81-263-37-2445

(for K.Shimano, the corresponding author)

Abstract

We investigated species composition and characteristics of plant communities in plots at seven site types within a ski resort: forests, an abandoned ski slope, an area under the gondola lines, forest waterfronts, open waterfronts, edges of ski slopes, and an active ski slope. On the abandoned ski slope, under the gondola lines, at the edges of ski slopes, and on the ski slope, canopy closure was low, tall herbs were present, and species diversity was high. Some wetland species were present at waterfront plots. Differential species composition was caused by vegetation cutting, which was necessary to manage the ski resort. We found various plants, including herbs, some of them are rarely seen because their habitats decreased. Despite their negative effects, such as soil surface

erosion and magnification of plant size due to the use of ammonium sulfate, ski resorts can be important plant habitats with highly diverse species composition.

Introduction

The vegetation of ski areas includes varied habitats for plants, such as herbaceous ski slopes, wet sites, and surrounding coppice forests. Coppice forests traditionally provided wood for fuel, fertilizer from litter, and edible wild plants. However, in Japan, the use of wood for fuel was abandoned in the 1960s in favor of propane gas. Moreover, the use of fertilizer from coppice forests decreased as progress was made with chemical fertilizer (Tabata 1997). The floors of these abandoned forests have darkened. As a result, many coppice forests have experienced little growth of forest floor plants. Furthermore, forest management practices, such as thinning, are now rare, due to the decrease in timber-self sufficiency after late 1970s (Shimazaki 1999). Japanese timber is more expensive than foreign timber, the interest in silviculture as a career has decreased, and silviculturists are older (Nihon-Ringyo-Chosakai 2002). Hence, there are few herbaceous plants under the dense canopies of mature plantation forests due to the lack of thinning (Shimano et al. 2006).

Other herbaceous plant habitats have also decreased. The total area of rice fields in Japan is falling due to the decrease in rice acreage implemented by the Japanese government, smaller numbers of farmers, and the aging of current farmers (Department of Statistics Information, Ministry of Agriculture, Forestry and Fisheries of Japan 2000). The distribution area of aletophytes, including rice field forbs, is also decreasing with the

use of agrichemicals (Tabata 1997; Hayashi and Tominaga 2004). A decrease of aletophytes is now feared (Serizawa 1995). Agricultural watercourses are being lined with concrete, and this habitat change is disturbing the distribution of many creatures (Kadono and Yuma 1995). Semi-natural meadows controlled by artificial burning are under succession to forests (Kurihara et al. 2001). Some plants, such as *Hedyotis diffusa* in rice fields and *Swertia pseudochinensis* in artificial meadows, are on the verge of extinction (Nagano Nature Conservation Research Institute 2002). Some semi-natural meadows serve as refugia for herbaceous plants (Suga 2008). But meadows dominated by *Miscanthus sinensis* are themselves endangered (Nagano Nature Conservation Research Institute 2005). The importance of semi-natural vegetation for endangered plant species continues to be emphasized (Fujii 1999, Nozaki 2007).

Ski resorts can have negative effects on plant communities, including the erosion of surface soil (Watson 1985), harmful effects for both plants and animals (Watanabe 1999; Bayfield 1980), and simplification of species composition and plant size magnification due to the use of ammonium sulfate to keep the snow cover from melting (Nakamura et al. 1999; Tatemoto and Nakamura 1999). However, ski resorts include many different plant habitats and may serve as refugia for herbaceous plants. Mowing and other ground cover management strategies may preserve plants that grow in secondary pastures.

Our study used vegetation surveys to clarify the role of ski resorts as refugia of herbaceous, wetland, and forest floor plants. At Fujimi Panorama Ski Resort in central

Japan, we investigated how different sites and management strategies, such as mowing, provide habitat for various plants.

Study Sites and Methods

Study sites

Fujimi Panorama Ski Resort is located in Fujimi, Nagano Prefecture, central Japan (N 35 54', E 138 12'). It is open not only in winter but also in summer for mountain biking. Elevation ranges from 1,080 to 1,780 m above sea level on the east-facing slope of Mt. Nyukasa (altitude 1,955 m). Annual mean temperature is 8.9°C in the lower elevations and 5.1°C in the higher elevations, and Kira's warmth index (WI; Kira 1949) is 67.7°C·month. Kira's WI is the sum of mean monthly temperatures above 5°C: $WI = \sum (\text{mean monthly temperature} - 5^\circ\text{C})$ only for warmer months averaging more than 5°C. The unit is °C·month. Annual precipitation is 1,412 mm, snowfall is usually from December to March, and maximum snow depth is shallow, at about 0.27 m (Meteorological Bureau 2000). Climax vegetation is Pacific Ocean-type beech forest co-dominated by deciduous and evergreen coniferous trees, estimated from WI and maximum snow depth (Shimano 2006).

This resort area sustains varied vegetation types in sites such as forests,

meadows on ski slopes, edges of ski slopes, and areas under gondola lines. We investigated species composition at these sites. The ski resort is surrounded by planted red pine (*Pinus densiflora*) and Japanese larch (*Larix kaempferi*) forests.

We established several plots at each of the following seven types of sites: (1) forests, (2) an abandoned ski slope, (3) an area under gondola lines, (4) forest waterfronts, (5) open waterfronts, (6) edges of ski slopes, and (7) an active ski slope. Each of these seven sites had a unique physiognomy, with homogeneous vegetation at each site type. In each site we set several plots for vegetation survey. Forests surrounded the ski slopes. *P. densiflora* and *L. kaempferi* dominated at heights of about 20 m. Although natural *P. densiflora* forests sometimes occur in Japan on mountain ridges or rocky habitats, in Nagano prefecture many mountain slopes are covered with planted *P. densiflora* forests (Yokouchi 1979), such as those around the ski slopes. The abandoned ski slope had been in use until 3 years before. Herbs and trees were regenerating naturally. The plots under the gondola lines were deforested, with tall herbaceous plants that were cut every 3 or 4 years. This vegetation was different from that of both the forests and the active ski slope. Forest waterfronts were artificial unlined channels in which plants grew naturally. Open waterfronts were the sides of artificial unlined channels used for drainage. The bank soil had not been artificially compacted, and water flow was low. In these forest and open waterfronts, the water level fluctuates with precipitation, with high levels in the early summer rainy season, autumn typhoon season, and snow melt season. However, the water

channels do not change. The vegetation along the edges of the ski slopes forms a belt between the ski slope and forests. Surveyed ski slope plots were in the center of the slopes and were mowed 3 or 4 times a year. Table 1 shows the frequency of cutting at each site according to resort officials.

Methods

Phytosociological investigation

We investigated species composition in each of 51 study plots at the 7 site types, using Braun-Blanquet's method (Braun-Blanquet 1964). The survey area, which differed in each plot, was set to encompass all of the species occurring in the plot. Plot sizes ranged from 2 m² in open and forest waterfront (channel) plots to 400 m² in forests. We identified the common species at each of the seven site types. Table 2 summarizes the species compositions of the sites. Scientific names are from Satake et al. (1989a, b). To calculate species diversity, we used the median of Braun-Blanquet's six-level cover degrees (+, 1 to 5) and calculated Shannon-Wiener's H' (bit).

We identified the Raunkiaer life form of all species (Raunkiaer 1934), using the divisions of Miyawaki et al. (1994) as follows:

- HH: Helophyte
Th: Therophyte
G: Geophyte
H: Hemicryptophyte
Ch: Chamaephyte
N: Nanophanerophyte
M: Mesophanerophyte
MM: Macrophanerophyte

We also recorded community heights. In coppice forests, community height minus planted trees was recorded to capture the natural growth of ground cover plants.

Measurement of canopy closure

To determine canopy closure as an index of light conditions, we took hemispherical photographs with a circular fisheye lens. We used a Coolpix 5400 digital camera with fisheye converter FC-E9 (Nikon, Tokyo, Japan). The camera was placed at a height of 1.5 m and set horizontally. After taking the pictures, we calculated the canopy closure rate with LIA 32 software for Windows (Yamamoto 2004).

Results

Vegetation at each site type

In total, we found 297 species in the 51 plots. The vegetation of each of the seven main study sites had a typical species composition (see Table 2).

Forest plots

Forests consisted mainly of planted red pine (*Pinus densiflora*) and larch (*Larix kaempferi*). The forest floor was predominantly covered by shrubs (*Ilex macropoda*, *Parabenzoin praecox*, *Viburnum dilatatum*, and *Rhus trichocarpa*), vines (*Rhus ambigua*), various ferns, and dwarf bamboo (*Sasa nipponica*). On some forest floors, *S. nipponica* dominated instead of tree species such as red pine or larch. Herbs, such as *Carex siderosticta* and *Disporum smilacinum*, which are prevalent species on the forest floor or in dark and wet sites, were also distributed. Community heights, not including planted canopy trees, were 9.75 ± 0.61 m (see Table 3), suggesting that the natural vegetation under canopy covers was mature.

Abandoned ski slope plots

Plots at this site contained tall herbs (*Miscanthus sinensis*, *Macleaya cordata*, and *Aster ageratoides* ssp. *ovatus*) and young, shade-intolerant woody plants (*Pinus densiflora*, *Betula platyphylla* var. *japonica*, and *Salix bakko*). Species composition differed from that of the plots under the gondola lines, although both site types had altherbosa and shade-intolerant, woody plants. On the abandoned ski slope, the heights of *B. platyphylla* var. *japonica* and *P. densiflora* were about 1.5 m, suggesting succession to woodlands.

Plots under the gondola lines

The site under the gondola lines was near forests and had the same brown forest soil; hence, the vegetation was similar to gap vegetation in the forests. The plots at this site were in between those of the ski slope and the forests. In the plots, altherbosa, such as *Artemisia princeps*, *Vicia cracca*, *Patrinia villosa*, *Aster ageratoides* ssp. *ovatus*, *Senecio cannabifolius*, *Desmodium podocarpium* ssp. *oxyphyllum*, and *Eupatorium chinense* var. *oppositifolium*, was dominant, along with woody plants, such as *Parabenzoin praecox*, *Deutzia crenata*, *Alnus japonica*, *Aralia elata*, *Alnus hirsuta* var. *sibirica*, *Hydrangea hirta*, *Rhus javanica* var. *roxburgii*, and *Betula platyphylla* var. *japonica*..

Sites at the edges of ski slopes

This site type, which was located between the ski slopes and forests, was distributed in a belt. *Solidago virgaurea* var. *asiatica*, *Patrinia villosa*, *Eupatorium chinense* var. *oppositifolium*, and *Eupatorium chinense* ssp. *sachalinense* were present as meadow herb species. We also found these species on the ski slope and along forest edges. In addition, we found *Hedyotis diffusa*, an endangered species in Nagano Prefecture.

Ski slope plots

Herbaceous plants such as *Trifolium repens*, *Poa sphondylodes*, and *Festuca arundinacea* grew on the ski slope. *Trifolium repens* and *F. arundinacea* are non-native species. We also found *Hydrocotyle sibthorpioides*, *Kummerowia striata*, *Geranium thunbergii*, and *Artemisia princeps*, which are lower-growing herbs.

Open waterfront sites

Open waterfronts contained the following herbaceous species: *Scirpus wichurae* (about 1 m tall) in the upper layers and *Persicaria sieboldii*, *Carex dickinsii*, *Carex*

dispalata, *Juncus effusus* var. *decipiens*, *Cyperus orthostachyus*, *Cyperus brevifolius* var. *leiolepis*, and *Hypericum laxum* in the lower layers (less than 0.3 m tall). These plants, which grow on open waterfronts and paths between rice fields and wetlands, were not present at any of the other six sites.

Forest waterfront plots

We found the aletophytes *Cryptotaenia japonica*, *Impatiens textori*, *Elatostema umbellatum* var. *majus*, *Hydrangea involucrata*, *Persicaria nepalensis*, *Chloranthus japonicus*, and *Boehmeria sylvestris* growing in dark, wet sites in montane zones. These species were not found at any of the other six site types we surveyed.

Canopy closure

Canopy closures by fisheye photographs were low on the ski slopes but high in the forest site type (see Table 3). Closure values were lowest on the active and abandoned ski slopes. Values increased at the open waterfronts, ski slope edges, under the gondola lines, forest waterfronts, and forests (see Table 3). There were significant differences between each relationship among sites, although there was no significant difference between forests and forest waterfronts, between the abandoned ski slope and the site

under the gondola lines, between the active and abandoned ski slope, and between the ski slope and open waterfronts (analysis of variance; protected least significant difference: PLSD).

Canopy closure and herb layer cover

Figure 1 shows the relationship between canopy closure and herb layer cover. We excluded dwarf bamboo, *Sasa nipponica*, in determining the relationship between forest floor brightness and herbaceous plant coverage, as dwarf bamboo reproduces by rhizome, and this cover does not reflect forest floor brightness. No canopy trees occurred on either the edges of the ski slopes or under the gondola lines, so canopy closure rates were low, but not zero because of the effects of surrounding forests. We found a significant negative correlation between canopy closure and ground cover ($p < 0.01$); thus, ground coverage decreased when canopy closure rate increased.

Raunkiaer's life forms

Higher vegetation tended to include more woody plants (see Fig. 2). In particular, the forest site type had many M and MM species, and 80% of the flora was woody species. The proportion of MM, M, and N species increased, and that of Th, G, and H species (e.g.,

herbs) decreased from the ski slope to the forest ($p < 0.001$, Spearman's rank method). H predominated in almost all site types but made up only 8% of vegetation in forests. In both forest and open waterfront sites, aletophytes of HH were common. The proportion of N at the abandoned ski slope, forest waterfronts, and site under the gondola lines was higher than that on the active ski slope.

Species diversity

Table 3 shows average species diversity according to Shannon-Wiener's H' (bit). The highest diversity index value was for forest waterfronts ($M = 4.51$ bit), followed by the site under the gondola lines, edges of the ski slope, open waterfronts, the abandoned ski slope, the active ski slope, and forests ($M = 2.93$ bit). Analysis of variance revealed that although there was no significant difference among forest, ski slope, and abandoned ski slope sites, such sites were significantly different from forest waterfronts, which had high species diversity ($p < 0.01$). Moreover, the ski slope and forest sites were significantly different from the edges of the ski slope and the site under the gondola lines ($p < 0.01$).

Canopy closure was highest in forest plots ($80.1 \pm 3.7\%$; see Table 3), and the diversity index was low. In contrast, canopy closure was lowest on the ski slope, but diversity was also low there, suggesting no direct relationship between canopy closure

and species diversity (see Table 3).

Discussion

Species characteristics of each site type

Forests

On the forest floor, we found typical plants of coppice forests, including *Rhus trichocarpa*, *Ilex macropoda*, *Rhus ambigua*, *Viburnum dilatatum*, and *Parabenzoin praecox*, which are common in *Pinus densiflora* forests. *Rhus trichocarpa* and *V. dilatatum* are typical of *Larix* plantations (Suzuki 1985), and *I. macropoda* grows in coppice forests (Miyawaki 1985). *Parabenzoin praecox* is characteristic of the *Parabenzoin praecocis*–*Zelcovetum* association and grows on concave slopes of mountain valleys and colluvial deposits (Miyawaki 1985). These species are common in *P. densiflora* and *L. kaempferi* plantations.

Abandoned ski slope

The abandoned ski slope was home to many shade-intolerant plants, such as

Miscanthus sinensis, *Pinus densiflora*, *Solidago virgaurea* var. *asiatica*, *Lysimachia clethroides*, *Aster ageratoides* ssp. *ovatus*, *Patrinia villosa*, *Viola grypoceras*, *Haloragis micrantha*, *Anaphalis margaritacea*, and *Swertia pseudochinensis* (see Table 2). *Pinus densiflora* was representative of shade-intolerant trees. *Solidago virgaurea* var. *asiatica*, *Lysimachia clethroides*, *Aster ageratoides* ssp. *ovatus*, and *Viola grypoceras* are characteristic of Arundinello–Miscanthion *sinensis*, a late succession community that follows Geranio–Zoysietum *japonicae* associations after grazing and burning are terminated (Kim 1985). *Patrinia villosa*, *Haloragis micrantha*, and *Anaphalis margaritacea* are primary components of the *Miscanthus sinensis* community. *Swertia pseudochinensis* is characteristic of the *Swertia japonica* subassociation of Arundinario chino–Miscanthetum *sinensis*, which typifies secondary meadow. These species and their community were taller than those of the ski slope, suggesting a succession from the ski slope.

Species diversity at the abandoned ski slope was less than that of the site under the gondola lines (see Table 3), although the time of the last mowing was the same. This suggests that forces other than mowing may affect species diversity. *Betula platyphylla* var. *japonica* and *Pinus densiflora* were dominant, and the trees were not germinated from stump or soil-seed pools but from newly dispersed anemochorous seeds. Koyama and Koyama (2002) also pointed out that surrounding vegetation affects the recovery of trees on abandoned ski slopes.

N, M, and MM species were more common here than on the active ski slope, as the invasion of woody plants coincided with the termination of mowing.

Site under the gondola lines

Plots at the site under the gondola lines contained shade-intolerant trees, shrubs, and perennial herbs as follows: *Aralia elata*, *Rubus crataegifolius*, *Rubus palmatus* var. *coptophyllus*, *Patrinia villosa*, *Pteridium aquilinum* var. *latiusculum*, *Lysimachia clethroides*, *Senecio cannabifolius*, *Aster ageratoides* ssp. *ovatus*, *Petasites japonicus*, *Macleaya cordata*, *Artemisia princeps*, *Senecio cannabifolius*, *Anaphalis margaritacea*, *Eupatorium chinense* var. *oppositifolium*, and *Cynoglossum asperrimum*. *Aralia elata*, *Rubus crataegifolius*, and *Rubus palmatus* var. *coptophyllus* are shade-intolerant woody plants growing in logged areas, and *Petasites japonicus* is a pioneer perennial herb growing in bare soil (Murakami 1985). In logged areas, we saw different vegetation that depended on human disturbance. The perennial herbs *Artemisia princeps*, *Lysimachia clethroides*, and *Pteridium aquilinum* var. *latiusculum* were found in the *Aralia elata*–*Rubus palmatus* var. *coptophyllus* community; the shade-intolerant scrubs *Aralia elata*, *Rubus crataegifolius*, *Rubus palmatus* var. *coptophyllus*, and *Macleaya cordata* are characteristic of *Youngio denticulatae*–*Macleayetum cordatae*; and *Senecio cannabifolius* and *Anaphalis margaritacea* occur in *Eupatorio*–*Epilobietum angustifolii* and

Anaphalido–Aruncetum kamtsuchatici, respectively (Murakami 1985). These associations are herb communities in an intermediate phase of succession. It is striking that some so-called tall herbs, such as *Eupatorium chinense* var. *oppositifolium*, *Senecio cannabifolius*, and *Cynoglossum asperrimum*, had heights ranging from 1.5 to 2 m.

This type of community depends on low, frequent mowing every 3 or 4 years, which results in high species diversity (see Table 3). More than 40% of woody species were high in the herbaceous community, and N, M, and MM species were highly dominant (see Fig. 2). In contrast, annual and perennial species occurred in Th, G, H, and Ch. Each Th, G, H, and Ch life form represented more than 8% of the flora at these plots. The fact that both woody and herbaceous plants grew under the gondola lines highlights the high species diversity of this site type.

Edges of ski slopes

The site on the edges of the ski slopes supported secondary meadow and logged-forest species like *Patrinia villosa*, *Solidago virgaurea* var. *asiatica*, *Eupatorium chinense* var. *oppositifolium*, *Cirsium oligophyllum*, *Reynoutria japonica*, *Petasites japonicus*, *Eupatorium chinense* ssp. *sachalinense*, *Rubia argyi*, *Clematis apiifolia*, *Viola grypoceras*, *Geranium thunbergii*, and *Trifolium repens*. All of these, as well as the average community height, were taller than the herbs on the ski slope (Table 3). *Patrinia*

villosa, *Solidago virgaurea* var. *asiatica*, *Eupatorium chinense* var. *oppositifolium*, *Cirsium oligophyllum*, *Petasites japonicus*, and *Viola grypoceras* are characteristic of *Miscanthion sinensis* in *Miscanthetea sinensis* associations of secondary meadows (Kim 1985). *Patrinia villosa*, *Eupatorium chinense* var. *oppositifolium*, *Petasites japonicus*, *Eupatorium chinense* ssp. *sachalinense*, and *Reynoutria japonica* are common in logged forest vegetation and landslide scar vegetation of *Petasiti japonici*–*Aralietalia cordatae* associations (Murakami 1985). *Reynoutria japonica*, *Eupatorium chinense* ssp. *sachalinense*, *Viola grypoceras*, *Rubia argyi*, and *Geranium thunbergii* are found in half-shaded forest-edge herb communities (Murakami 1985). Of ski slope species, *Poa sphondylodes* and *Trifolium repens* were also found here. Thus, the vegetation consisted of secondary grasslands of *Miscanthus sinensis*, logged-forest vegetation, landslide scar vegetation, forest edge vegetation, and ski slope vegetation.

Species diversity was high at the edges of ski slopes (see Table 3). *Patrinia villosa*, *Solidago virgaurea* var. *asiatica*, and *Cirsium oligophyllum* are species of secondary meadows of Utsukushigahara and Kirigamine highlands (Murakami 1985, Miyawaki 1994).

Compared to those of the ski slope, rates of Ch, N, M, and MM were higher at the edges of the ski slopes. This implies that much taller species can grow in the edge site, which is less mowed than the ski slope (Table 1).

Ski slope

On the ski slope, we found *Poa sphondylodes*, *Trifolium repens*, *Stenactis annuus*, *Kummerowia striata*, *Geranium thunbergii*, *Festuca arundinacea*, *Artemisia princeps*, *Erigeron canadensis*, *Solidago virgaurea* var. *asiatica*, *Hydrocotyle sibthorpioides* and *Plantago asiatica* (see Table 2). *Trifolium repens* and *Festuca arundinacea* originated from seeds sown during the creation of the ski slope. Such pasture grasses have also been reported on a ski slope in Hakuba, Nagano Prefecture (Nakamura 1988). *Geranium thunbergii*, *Artemisia princeps*, *Kummerowia striata*, *Erigeron canadensis*, and *Solidago virgaurea* var. *asiatica* are common species of Geranio–Zoysietum japonicae associations of *Zoysia japonica* in Miscanthetia sinensis; the species composition of Geranio–Zoysietum japonicae associations is like grazing ground (Miyawaki et al. 1994). The *Zoysia japonica* community is low-height pasture due to human disturbances, such as grazing, burning, mowing, and trampling (Kim 1985). In addition, in some plots we found *Hydrocotyle sibthorpioides* and *Plantago asiatica*, which are resistant to trampling. Such low plants are common because of mowing on the ski slope and trampling by sightseers and mountain bikes (see Table 1). Moreover, the *Zoysia japonica* community retrogressively succeeds to Plantaginetalia asiatica with more simple species composition due to excessive mowing or trampling (Kim 1985). In lower parts of the ski slope, we found high cover of *Plantago asiatica*,

suggesting that such retrogressive succession might be occurring. In a ski slope in Tobu-Yunomaru, Nagano Prefecture, Nakamura (1988) reported that *Plantago asiatica*, *Trifolium repens*, and *Dactylis glomerata* grew as a result of heavy trampling.

Canopy closure here was the lowest (Table 3), and plants grew in sunny conditions. H dominated the flora. The ski slope rates of N, M, and MM were the lowest among the study sites. This reflects the frequency of mowing, which was the highest among the study sites (Table 1). Species diversity here is also low due to heavy mowing.

Open waterfronts

Open waterfronts supported wetland species such as *Scirpus wichurae*, *Hypericum laxum*, *Persicaria sieboldii*, *Carex dispalata*, *Juncus leschenaultii*, *Cyperus brevifolius* var. *leiolepis*, and *Cyperus orthostachyus* (see Table 2). *Scirpus wichurae* and *Hypericum laxum* are members of the Isachno–Caricetum thunbergii association of low moor vegetation. Low moor vegetation occurs in areas of standing water due to incoming water and poor discharge in valley bottoms in mountain areas or back marshes of rivers (Okuda 1985). Okuda pointed out that this community also occurs in fallow rice fields as an intermediate phase of succession. *Carex dispalata* is characteristic of Caricetum dispalatae, one of the most widespread forms of low moor vegetation. Caricetum dispalatae usually occurs in large-scale back marshes and sometimes occurs in a belt

along the edges of flowing water in mountainous areas (Okuda 1985). *Juncus leschenaultii*, *Hypericum laxum*, *Cyperus brevifolius*, and *Persicaria sieboldii* have been found in *Juncus leschenaultii* communities in wet paddy fields abandoned for 1 year (Shimoda 1996). *Cyperus brevifolius* var. *leiolepis* is a typical plant of *Eupatorium lindleyanum*–*Ischaemum aristatum* var. *glaucum* communities in year-round wet rice fields abandoned for 2 or 3 years. *Cyperus orthostachyus* is also characteristic of *Vandellietum angustifoliae* associations of riparian flood herbaceous vegetation that occur in riparian sites that experience overhead flooding during the rainy season (Okuda 1985) and where succession is delayed by water flow disturbances. This *Vandellietum angustifoliae* site, in sedimentary mud along the waterfront, was typical of riparian vegetation sometimes affected by floods.

The open waterfront plots contained species typically found in low moor vegetation, abandoned rice fields, and riparian flood herbaceous vegetation. The unlined channel we surveyed was artificial and unpaved. Canopy openness was high, and the site was brightly lit (see Fig. 1 and Table 3), with slow and low water flow (pers. obs.). This is a similar environment to rice fields and natural wetlands. Wetland vegetation has decreased throughout Japan because of the decrease in natural wetlands and rice fields (Kadono and Yuma 1995, Geographical Survey Institute, Japan 2000, Sasaki 2001, Ohkuro et al. 2003). Therefore, open waterfronts at ski resorts will play a role as hydrophyte and aletophyte habitat in the face of declining wetlands and rice fields.

Forest waterfronts

Forest waterfronts were home to *Impatiens textori*, *Cryptotaenia japonica*, *Elatostema umbellatum* var. *majus*, *Hydrangea involucrata*, *Persicaria nepalensis*, *Boehmeria sylvestris*, and *Chloranthus japonicus*. Ohno (1985) noted that *E. umbellatum* var. *majus* and *Hydrangea involucrata* are widespread forest floor species in various mountain riparian communities. *Persicaria nepalensis* is found in high-moisture sites, such as wetlands or on paths between rice fields, *I. textori* in shaded wetlands and flowing waterfronts, and *C. japonica* on forest floors. *B. sylvestris*, *C. japonicus*, and *E. umbellatum* var. *majus* are common in *Zelkova serrata* riparian forests in Pacific Ocean climates.

These species occur in wet environments, such as riparian areas, waterfronts, and valleys, and we found these plants among shaded, wet vegetation. This site type had species in common with natural riparian forests, although the artificial channel was beside a forest road. Thus, the species composition here was similar to that of natural waterfront habitats in mountainous areas.

The forest waterfront site type had the highest H' values for species diversity (4.51 ± 0.39 bit; see Table 3) due to water flow disturbance. The environment was characterized by high moisture and shade beneath the forest canopy.

Change in life forms

The forest site had many N, M, and MM trees (Fig. 2) due to the lack of mowing. In contrast, the other six site types had many Th, G, H, and Ch herb species. At waterfront plots, water flow disturbance delayed succession. The ski slope, abandoned ski slope, and site under the gondola lines were affected by mowing. These different disturbance regimes resulted in differences in life form composition between the forest and other site types. Although N plants were common at the abandoned ski slope, forest waterfronts, and the site under the gondola lines, their values were less than those for the forest. This suggests that disturbances like mowing or water flow at the former three sites were less than that at the ski slope.

Role of ski resorts

Two factors affect vegetation in the ski resort studied. The first is habitat condition, including water and light. In the ski-resort waterfronts, many species are those of natural waterfronts. The distribution of species in open- and closed-canopy waterfronts differs by canopy openness. Closed-canopy waterfronts contain mountain riparian species (Ohno 1985) such as *Elatostema umbellatum* var. *majus*, *Hydrangea involucrate*, and *Impatiens textori*, whereas open-canopy waterfronts contain low moor species

(Okuda 1985) such as *Scirpus wichurae*, *Hypericum laxum*, and *Carex dispalata*.

The second factor is the frequency of mowing related to resort management. Different site types experience different frequencies of mowing (Table 1) and different rates of vegetation succession following the disturbance (Fig. 2). It is difficult for ski slope vegetation to mature because of frequent mowing (3 times per year). The abandoned ski slope and the site under the gondola lines, where the frequency of mowing is not high (Table 1), have tall vegetation and varied herb species. In contrast, forest plot communities are typical of artificial *Pinus densiflora* and *Larix kaempferi* forests.

The vegetation found in the ski resort is a complex combination of rice field, waterfront, secondary meadow, forest landslide scar, and logged area species. Each site type has a specific plant community (Table 2). For example, the open waterfront community plays the same role as do rice fields and natural waterfronts. Some species typical of low moors or rice fields, such as *Scirpus wichura*, *Hypericum laxum*, *Juncus leschenaultii*, and *Persicaria sieboldii*, are present (Table 2; Okuda 1985, Shimoda and Suzuki 1981). Waterfronts under forests contain *Elatostema umbellatum* var. *majus* and *Hydrangea involucrate*, which are mountain riparian forest species (Ohno 1985). The sites at the edges of ski slopes and under the gondola lines contain vegetation found in forest landslide scars and secondary meadows. For example, *Macleaya cordata*, *Patrinia villosa*, *Eupatorium chinense*, and *Petasites japonicus* occur in forest landslide scar and logged areas (Murakami 1985, Kim 1985). The abandoned ski slope site is like a

secondary meadow, with *Solidago virgaurea*, *Aster ageratoides* spp.*ovatus*, and *Patrinia villosa* (Miyawaki et al. 1994).

The resort is a refugium for various species, some of which are endangered, such as as *Hedyotis diffusa*, found in sites at the edges of ski slopes, and *Swertia pseudochinensis*, found in the abandoned ski slope site. Moreover, although many waterfront species are not necessarily endangered, waterfront habitats are decreasing (Kadono and Yuma 1995, Sasaki 2001, Ohkuro et al. 2003, Geographical Survey Institute, Japan 2000). Altherbosa in rice fields is also decreasing due to agricultural chemical use, the decrease in rice fields, and the increase of cemented banks (Tabata 1997). At the ski resort, waterfront habitats are not likely to change, and the resort studied does not use agricultural chemicals at its waterfront sites. Therefore, these communities are more natural than their counterparts in rice fields. Semi-natural meadows are also considered to be refugia for herbaceous plants (Suga 2008). These *Miscanthus-sinensis*-dominated meadows are also endangered (Nagano Nature Conservation Research Institute 2005). Not only is meadowland disappearing in Japan (Kurihara et al. 2001), but so are herbaceous species of well-managed secondary and artificial forests because of shade conditions. Coppice and artificial forests used for timber are being abandoned, as these resources are no longer needed for fertilizer and fuel, and timber from developing countries is inexpensive (Tabata 1997; Nihon-Ringho-Chosakai 2002). However, the ski resort preserves semi-natural meadow habitats at the edges of ski slopes and on

abandoned ski slopes , where *Patrinia villosa*, *Haloragis micrantha*, *Eupatorium chinense* var. *oppositifolium*, and other meadow species are present (Table 2). The total area of such waterfronts and secondary meadows may not be large, but these sites are important, because management will help maintain species distribution in the long term. In this respect, ski resorts play a role in the conservation and diversity of herb species.

Furthermore, ski resorts also play a role in the ecological education of young people. Resorts are usually easy to access and have facilities such as restrooms, gondolas, and/or lifts. Thus, people who are not comfortable hiking or climbing mountains can easily use ski resorts to learn about ecology and nature.

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Captions

Figure 1. Relationship between canopy closure of trees and coverage of herb layer.

Figure 2. Ratios of Raunkiaer's life form in seven site types.

HH: Helophyte, Th: Therophyte, G: Geophyte, H: Hemicryptophyte, Ch: Chamaephyte,

N: Nanophanerophyte, M: Mesophanerophyte, MM: Macrophanerophyte.

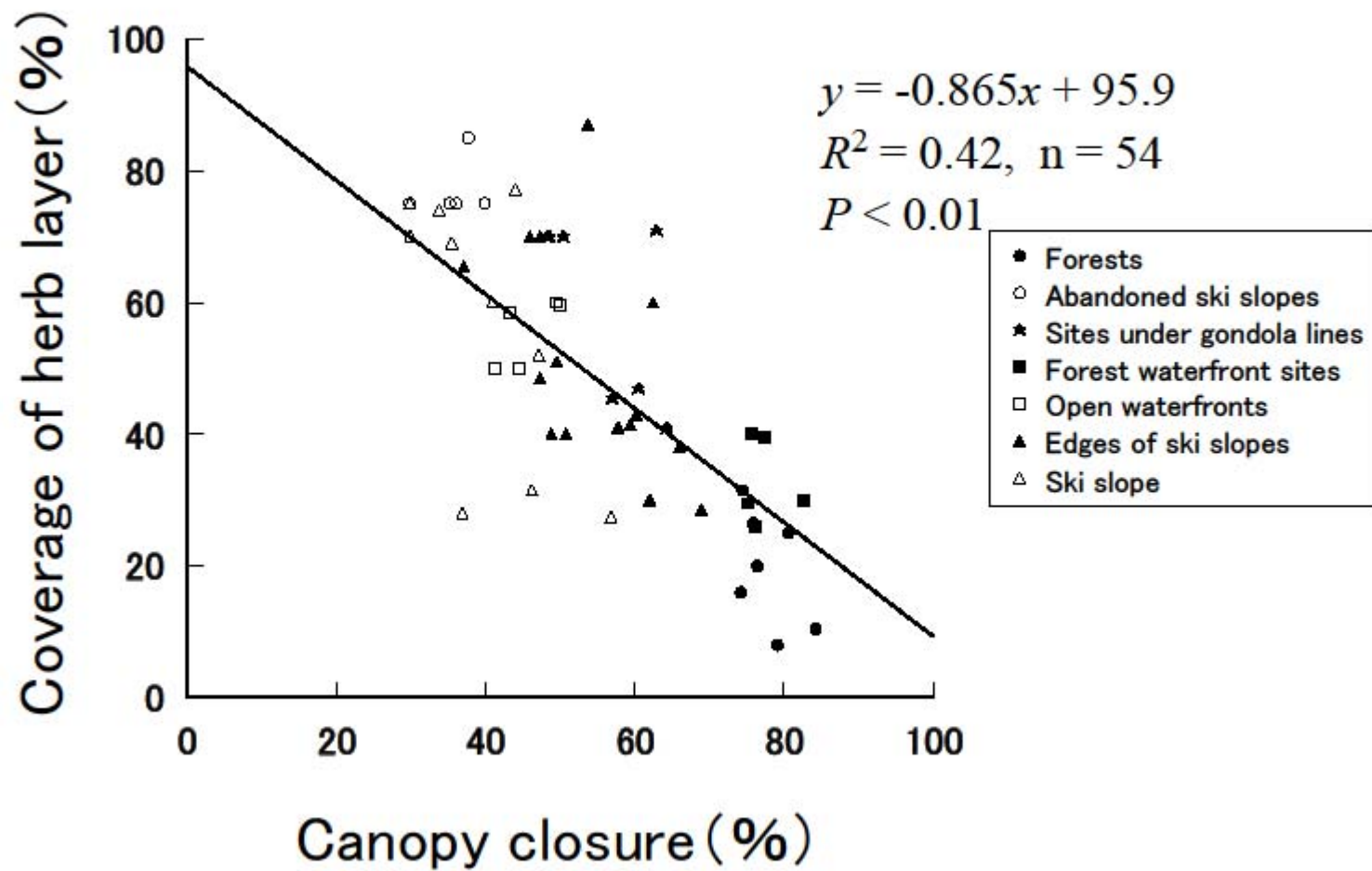


Figure 1.

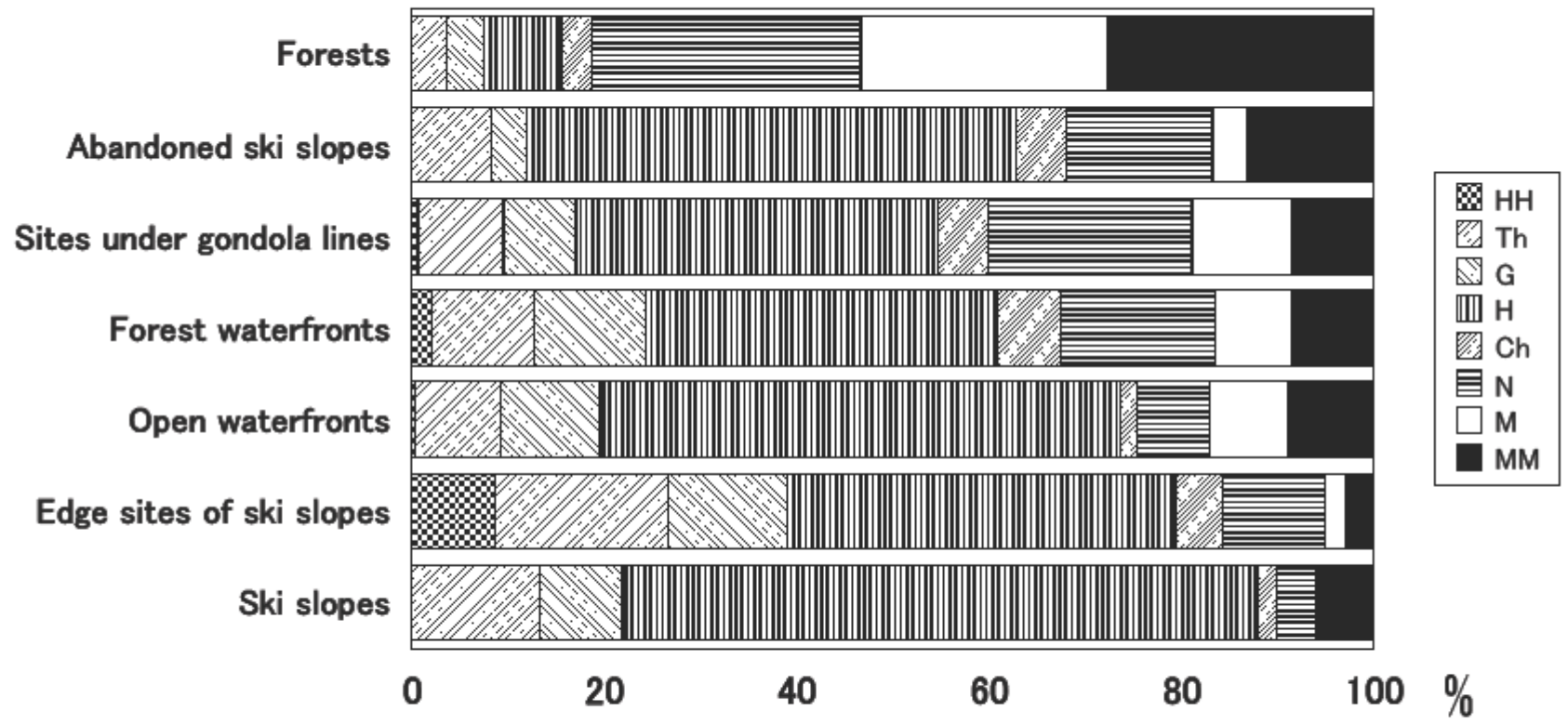


Figure 2.

Table 1. Characters and managements of each site.

Sites	Situation	Maximum community heights	Mowing management	No. of study sites
1 Forests	stands of <i>Pinus densiflora</i> and <i>Larix kaempferi</i>	20m	No	6
2 Abandoned ski slopes	Pasture of weed and shade intolerant woods	1.5m	Abundant in three years	5
3 Sites under gondola lines	Secondary pasture	1.3m	mowed every 3 or 4 years	6
4 Forest waterfronts	unlined ditch for drainage under forest canopy	0.8m	No	6
5 Open waterfronts	Altherbosa along unlined ditch for drainage in open ai	0.8m	No	6
6 Edges of skislopes	Secondary pasture between forests and ski slopes	1.3m	No	16
7 Ski slopes	Weeds	0.8m	mowed 3 or 4 times per	9

Table 2. Synthetic table of seven sites in Fujimi ski resort.

Species	Forests	Abundant ski slopes	Under gondola lines	Edges of ski slopes	Ski slopes	Open waterfronts	Forest waterfront s	cited in body text	Japanese name
<i>Ilex macropoda</i>	IV							F	Aohada
<i>Viburnum dilatatum</i>	IV			I			I	F	Gamazumi
<i>Castanea crenata</i>	IV		II	II	I		I		Kuri
<i>Acanthopanax sciadophylloides</i>	IV			I					Koshiabura
<i>Symplocos chinensis</i> var. <i>leuc</i>	IV		I						Sawafutagi
<i>Lindera obtusiloba</i>	IV			I					Dankoubai
<i>Rhus trichocarpa</i>	IV	I		I				F	Yamaurushi
<i>Acer rufinerve</i>	III		II	I			I		Urihadakaede
<i>Magnolia praecocissima</i>	III		I	I					Kobushi
<i>Chamaecyparis obtusa</i>	III			I			II		Hinoki
<i>Clematis apiifolia</i>	III			I					Botanduru
<i>Prunus maximowiczii</i>	III			I			I		Miyamazakura
<i>Clethra barbinervis</i>	III		I	I					Ryoubu
<i>Vaccinium hirtum</i>	II			I					Usunoki
<i>Acer crataegifolium</i>	II			I					Urikaede
<i>Disporum smilacinum</i>	II			I				F	Chigoyuri
<i>Acer palmatum</i>	II								Irohantomiji
<i>Viburnum erosum</i> var. <i>punctata</i>	II								Kobanogamazumi
<i>Euonymus alatus</i> f. <i>ciliato-dent</i>	II								Komayumi
<i>Styrax obassia</i>	II								Haku-unboku
<i>Cornus controversa</i>	II								Mizuki
<i>Viburnum wrightii</i>	II								Miyamagamazumi
<i>Prunus jamasakura</i>	II								Yamazakura
<i>Carex siderosticta</i>	II		II					F	Taganesou
<i>Duchesnea chrysantha</i>		V	I	IV	III	III	II		Hebi-ichigo
<i>Stenactis annuus</i>		II	III	IV	IV	V	III	SS	Himejohn
<i>Plantago asiatica</i>		II	I	V	V	V	III	SS	Ohbako
<i>Taraxacum officinale</i>		IV	I	IV	V	IV	II		Seiyoutanpopo
<i>Amphicarpaea bracteata</i> ssp.	I		II	II	I	I	V		Yabumame
<i>Viola grypoceras</i>	I		IV	V	IV	II	II	ASS, ESS	Tachitsubsumire
<i>Rubus palmatus</i> Thunb. var. <i>coptophyllus</i> .			II	III	II	I	V	UGL	Momiji-ichigo
<i>Rubus microphyllus</i>		V	V	V	III	V	I		Nigaichigo
<i>Artemisia princeps</i>		V	V	V	V	V	I	UGL, SS	Yomogi
<i>Patrinia villosa</i>		V	V	IV	I	II	I	ASS, UGL, ES	Otokoeshi
<i>Lysimachia clethroides</i>		III	V	II	II	IV		ASS, UGL	Okatorano-o
<i>Solidago virgaurea</i> var. <i>asiatica</i>		III	I	IV	I	I		UGL, ESS, SS	Akinokirinsou
<i>Anaphalis margaritacea</i>		III	I	III	II	I		ASS	Yamahahako
<i>Macleaya cordata</i>		V	II	II	II	II		ASS, UGL	Takenigusa
<i>Aster ageratoides</i> ssp. <i>ovatus</i>		III	I	I	II	I		ASS, UGL	Nokongiku
<i>Miscanthus sinensis</i>		IV		I	II	II		ASS	Susuki
<i>Betula platyphylla</i> var. <i>japonica</i>		V	III	II	II		I	ASS, UGL	Shirakaba
<i>Salix bakko</i>		III	I	II		II		F	Bakkoyanagi
<i>Haloragis micrantha</i>		V		I				ASS	Arinotohgusa
<i>Hypericum kamtschaticum</i> var. <i>senanense</i>		III		I					Shinano-otogiri
<i>Enkianthus cernuus</i> f. <i>nipponicus</i>		III							Benidouandan
<i>Swertia japonica</i>		II		I				ASS	Senburi
<i>Swertia pseudochinensis</i>		I						ASS	Murasakisemburi
<i>Petasites japonicus</i>			V	II	II	V	IV	UGL, ESS	Fuki
<i>Geranium thunbergii</i>			II	II	II	II	III	ESS, SS	Gennoshoko
<i>Elsholtzia ciliata</i>			I	I	II	II	I		Naginatakouju
<i>Trifolium repens</i>		I	III	V	V			ESS, SS	Shirotsunekusa
<i>Hypericum erectum</i>			IV	II	II	II			Otogirisou
<i>Eupatorium chinense</i> var. <i>oppo</i>	I		V	I				UGL, ESS	Hiyodoribana
<i>Alnus japonica</i>			V					UGL	Hannoki
<i>Deutzia crenata</i>	I		V	I	I		II	UGL	Utsugi
<i>Clematis apiifolia</i> var. <i>biternata</i>			V				I		Kobotanduru
<i>Rabdosia inflexa</i>			IV				I		Yamahakka
<i>Alnus hirsuta</i> var. <i>sibirica</i>	I		III	I		I		UGL	Yamahannoki
<i>Spiraea japonica</i>			III				I		Shimotsuke
<i>Aralia elata</i>	I		III	II			I	UGL	Taranoki
<i>Vicia cracca</i>			III	I				UGL	Kusafuji
<i>Clinopodium chinense</i> var. <i>parviflorum</i>			III		I				Kurumabana
<i>Galium trachyspermum</i>			III	I					Yotsubamugura
<i>Rhus javanica</i> var. <i>roxburgii</i>			II			I		UGL	Nurude
<i>Carpinus laxiflora</i>	I		II				I		Akashide
<i>Cynoglossum asperrimum</i>			II					UGL	Onirurisou
<i>Zanthoxylum piperitum</i>	I		II				I		Sansyou
<i>Dioscorea gracillima</i>			II						Tachidokoro
<i>Aquilegia buergeriana</i>			II						Yamaadamaki
<i>Akebia quinata</i>	I		II	I					Akebi
<i>Kummerowia striata</i>				II	IV	II		SS	Yahazusou
<i>Setaria viridis</i>		I		I	II	III			Enokorogusa
<i>Stachys riederi</i> var. <i>intermedia</i>		III		II	II	V			Inugoma
<i>Equisetum arvense</i>	I			II	I	V			Sugina
<i>Festuca arundinacea</i>			I	I	III	II		SS	Oni-ushinokegusa
<i>Reynoutria japonica</i>	I	I		IV	II		II	ESS	Itadori
<i>Poa sphondylodes</i>		II	I	III	III			SS	Ichigotsunagi
<i>Cirsium oligophyllum</i>				III	I			ESS	Nohara-azami
<i>Nepeta cataria</i>			I	II	II			ESS	Inuhakka
<i>Dactylis glomerata</i>				II	II				Kamogaya
<i>Lespedeza cuneata</i>		I	I	I	II				Medohagi
<i>Picris hieracioides</i> var. <i>glabrescens</i>				I	II				Kouzorina
<i>Achillea millefolium</i>				I	II				Seiyounokogirisou
<i>Eupatorium chinense</i> ssp. <i>sachalinense</i>				II	I			ESS	Yotsubahiyodoribana

Table 2. continued

Species	Forests	Abundant ski slopes	Under gondola lines	Edges of ski slopes	Ski slopes	Open waterfronts	Forest waterfronts	cited in body text	Japanese name
<i>Bidens frondosa</i>			II			V			Amerikasendangusa
<i>Trifolium pratense</i>				I	II	IV			Akatsumekusa
<i>Scirpus wichurae</i>						IV		OW	Aburagaya
<i>Persicaria sieboldii</i>				I		III		OW	Akinounagitsukami
<i>Carex dickinsii</i>						III		OW	Onisuge
<i>Mosla punctulata</i>						II			Inukouju
<i>Juncus leschenaultii</i>						II		OW	Kougaizekisyuu
<i>Hypericum laxum</i>						II		OW	Kokeotogih
<i>Clinopodium gracile</i>						II			Toubana
<i>Halenia corniculata</i>						II			Hanaikari
<i>Eleocharis congesta</i>						II			Hari-I
<i>Carex mollicula</i>						II			Himeshirasuge
<i>Carex dispalata</i>			I			II		OW	Kasasuge
<i>Fragaria nipponia</i>			I			II			Shirobanahebi-ichigo
<i>Juncus effusus</i> var. <i>decipien</i>						II		OW	Igusa
<i>Impatiens textori</i>			II	I		II	V	FW	Tsurifunesou
<i>Boehmeria spicata</i>			II			I	IV		Koakaso
<i>Clinopodium micranthum</i>			I	I			IV		Inutohban
<i>Hydrangea involucrata</i>							IV	FW	Tama-ajisai
<i>Cryptotaenia japonica</i>			I				IV	FW	Mitsuba
<i>Oplismenus undulatifolius</i>					II	I	III		Kechijimizasa
<i>Struthiopteris niponica</i>	II		I	I			III		Shishigashira
<i>Boehmeria sylvestris</i>			II				III	FW	Akaso
<i>Galium kikumugura</i>							III		Kikumugura
<i>Ranunculus silerifolius</i>							III		Kitsunenobotan
<i>Actinidia arguta</i>							III		Sarunashi
<i>Chamaecyparis pisifera</i>	I						III		Sawara
<i>Serratula coronata</i> ssp. <i>insularis</i>							III		Tamurasou
<i>Chloranthus japonicus</i>							III	FW	Hitorishizuka
<i>Astilbe thunbergii</i>							III		Toriashisyoma
<i>Pilea pumila</i>							II		Aomizu
<i>Elatostema umbellatum</i> var. <i>majus</i>							II	FW	Uwabamisou
<i>Carpesium divaricatum</i>							II		Gankubisou
<i>Galium trifloriforme</i> var. <i>nipponicum</i>							II		Kurumamugura
<i>Viola spiecies</i>							II		Sumire sp.
<i>Persicaria nepalensis</i>							II	FW	Tanisoba
<i>Isachne globosa</i>							II		Chigozasa
<i>Sasa nipponica</i>	V	V		IV	I	I	IV	F	Miyakozasa
<i>Pinus densiflora</i>	V	V		II	II		I	ASS	Akamatsu
<i>Parabenzoïn praecox</i>	V		V				IV	F, UGL	Aburachan
<i>Rhus ambigua</i>	V		I	II			III	F	Tsutaurushi
<i>Hydrocotyle sibthorpioides</i>		I		I	I			SS	Chidomegusa
<i>Desmodium podocarpium</i> ssp. <i>oxyphyllum</i>			II	II			II	UGL	Nusubitothagi
<i>Rubus crataegifolius</i>	I		II				I	UGL	Kumaichigo
<i>Erigeron canadensis</i>		I	I		II			SS	Himemukashiyomogi
<i>Rubia argyi</i>			I	I			I	ESS	Akane
<i>Senecio cannabifolius</i>			I					UGL	Hangonsou
<i>Hedyotis diffusa</i>				I				ESS	Futabamugura
<i>Cyperus orthostachyus</i>						I		OW	Uchikugu
<i>Cyperus brevifolius</i> var. <i>leiolepis</i>						I		OW	Himekugu
<i>Pteridium aquilinum</i> var. <i>latiusculum</i>			II	II	I			UGL	Warabi
<i>Hydrangea hirta</i>	III		II	I			III		Koajisai
<i>Actinidia polygama</i>	I								Matabi
<i>Corylus sieboldiana</i>	IV	V	I	I			I		Tsunohashibami
<i>Lonicera gracilipes</i>	III	IV		I					Yamauguisukagura
<i>Larix kaempferi</i>	III	IV	I	II		I	I		Karamatsu
<i>Hydrangea macrophylla</i> var. <i>ac</i>	III	II	III	I			III		Yama-ajisai
<i>Hosta montana</i>			II	I					Ohbagiboushi
<i>Campanula punctata</i> var. <i>hondoensis</i>			II	I					Yamahotarubukuro
<i>Euphorbia pekinensis</i>				I					Takadoudai
<i>Calystegia japonica</i>				I		I			Hirugao
<i>Viola verecunda</i>				I		I			Tsubosumire
<i>Aster glehnii</i> var. <i>hondoensis</i>				I		I			Gomana
<i>Persicaria longiseta</i>				I	I	II			Inutate
<i>Potentilla freyniana</i>		I		I		II			Mitsubatsuchiguri
<i>Ixeris dentata</i>			I	I	I				Nigana
<i>Phleum pratense</i>				I	I				Ohawagaeri
<i>Alopecurus pratensis</i>				I	I				Ohsumenoteppou
<i>Zoysia japonica</i>				I	I				Shiba
<i>Circaea erubescens</i> Franch				I	I				Tanitade
<i>Calamagrostis arundinacea</i> var. <i>brachytricha</i>				I	I				Nogariyasu
<i>Lysimachia japonica</i> f. <i>subsessilis</i>				I	II	II			Konasubi
<i>Smilax sieboldii</i>	II		I				II		Yamakasyu
<i>Phryma leptostachya</i> ssp. <i>asi</i>	I						II		Haedokusou
<i>Akebia trifoliata</i>	I						II		Mitsuba-akebi
<i>Chloranthus serratus</i>	I		I				II		Futarishizuka
<i>Berchemia racemosa</i>	I		I				II		Kumayanagi
<i>Paederia scandens</i>				I			II		Hekusokazura
<i>Festuca ovina</i>				I	II	I			Ushinokegusa
<i>Epilobium pyrricholophum</i>				I		I	II		Akabana
<i>Cryptomeria japonica</i>						I	II		Sugi
<i>Hydrangea paniculata</i>	I	II	II	II	I		I		Noriutsugi
<i>Metaplexis japonica</i>	I				II		I		Gagaimo
<i>Ligularia dentata</i>				II					Marubautsugi
<i>Torilis japonica</i>				I			I		Yabujirami
<i>Oxalis corniculata</i>				I		I	I		Katabami
<i>Zelkova serrata</i>	II						I		Keyaki
<i>Euonymus oxyphyllus</i>	II		I				I		Tsuribana
<i>Cimicifuga simplex</i>			I				I		Sarashinasyoma

Table 2. continued

Species	Forests	Abandant ski slopes	Under gondola lines	Edges of ski slopes	Ski slopes	Open waterfronts	Forest waterfront s	cited in body text	Japanese name
<i>Quercus serrata</i>	I		II	III					Konara
<i>Ligustrum tschonoskii</i>	II		I						Miyamaibota
<i>Astilbe microphylla</i>						I	I		Chidakasashi
<i>Celastrus orbiculatus</i>		I	I	I			I		Tsuru-umemodoki
<i>Carex</i> species	I	II							Suge sp.
<i>Youngia denticulata</i>			I	I		II			Yakushisou
<i>Duchesnea indica</i>					II				Yabuhebi-ichigo
<i>Dryopteris crassirhizoma</i>				I					Oshida
<i>Setaria pumilla</i>				I					Kin-enokoro
<i>Oenothera biennis</i>			I	I					Mematsuyoigusa
<i>Kalimeris yomena</i>			I	I					Yomena
<i>Lycopodium clavatum</i>				I					Hikagenokazura
<i>Smilax biflora</i> var. <i>trinervula</i>	I		I						Sarumame
<i>Acer mono</i>	I								Itayakaede
<i>Taxus cuspidata</i>	I								Ichii
<i>Carpinus tschonoskii</i>	I								Inushide
POACEAE species	I								Ine sp.
<i>Dioscorea nipponica</i>	I								Uchiwadokoro
<i>Abies homolepis</i>	I			I					Urajiromomi
<i>Prunus grayana</i>	I								Uwamizuzakura
<i>Acer mono</i> f. <i>marmoratum</i>	I								Enkoukaede
<i>Viburnum furcatum</i>	I								Ohkamenoki
<i>Moehringia lateriflora</i>	I								Ohyamafusuma
<i>Viburnum phlebotrichum</i>	I								Otokoyouzome
<i>Pourthiaea villosa</i> var. <i>laevis</i>	I								Kamatsuka
<i>Acer sieboldianum</i>	I								Kohauchiwakaede
<i>Acer micranthum</i>	I								Kominekaede
<i>Cephalanthera longibracteata</i>	I								Sasabaginran
<i>Euonymus melananthus</i>	I								Sawadatsu
<i>Lonicera japonica</i>	I								Suikazura
<i>Rosa multiflora</i>	I								Noibara
<i>Schisandra repanda</i>	I								Matsubusa
<i>Lycopodium obscurum</i>	I								Man-nensugi
<i>Quercus mongolica</i> ssp. <i>crispu</i>	I								Mizunara
<i>Meliosma tenuis</i>	I								Miyamahahako
<i>Rhododendron obtusum</i> var. <i>ka</i>	I								Yamatsutsuji
<i>Kerria japonica</i>	I								Yamabuki
<i>Acer amoenum</i> var. <i>matumura</i>	I								Yamamomiji
<i>Rhododendron japonicum</i>	I								Rengetsutsuji
<i>Acer aidzuense</i>	I								Karakogikaede
<i>Helwingia japonica</i>	I								Hanaikada
<i>Actinidia kolomikta</i>	I						I		Miyamamatatabi
<i>Salix integra</i>		I				I			Inukoriyanagi
<i>Zanthoxylum schinifolium</i>		I							Inuzansyou
<i>Trisetum bifidum</i>		I							Kanitsurigusa
<i>Aphananthe aspera</i>		I							Mukunoki
<i>Astilbe thunbergii</i>			I						Akasyoma
<i>Cirsium spicis</i>			I						Azami sp.
<i>Epigaea asiatica</i>			I						Iwawashi
<i>Sanicula chinensis</i>			I						Umanomitsuba
<i>Rubus phoenicolasius</i>			I						Ebigaraichigo
<i>Humulus japonicus</i>			I						Kanamugura
<i>Trollius hondoensis</i>			I						Kinbaisou
<i>Hosta sieboldii</i> f. <i>lancifolia</i>			I						Kobagiboushi
<i>Clematis terniflora</i>			I						Senninsou
<i>Rosa wichuraiana</i>			I						Terihanoibara
<i>Lychnis miqueliana</i>			I						Fushigurosennou
<i>Lespedeza cyrtobotrya</i>			I						Marubahagi
<i>Galium spurium</i> var. <i>echinosperman</i>			I						Yaemugura
<i>Actaea asiatica</i>			I						Ruiyousyouma
<i>Luzula capitata</i>				I					Suzumenoyari
<i>Commelina communis</i>				I					Tsuyukusa
<i>Cirsium japonicum</i>				I					Noazami
<i>Achillea alpina</i>				I					Nokogirisou
<i>Ambrosia artemisiifolia</i> var. <i>elatior</i>				I					Butakusa
<i>Pyrola incarnata</i>				I					Benibanaichiyakusou
<i>Maianthemum dilatatum</i>				I					Maizurusou
<i>Pyrola nephrophylla</i>				I					Marubaichiyakusou
<i>Lactuca indica</i>				I					Akinonogeshi
<i>Pyrola japonica</i>				I					Ichiyakusou
<i>Ranunculus japonicus</i>				I					Umanoashigata
<i>Cynodon dactylon</i>				I					Gyougishiba
<i>Clerodendrum trichotomum</i>				I					Kusagi
<i>Agrostis alba</i>				I					Konukagusa
<i>Pyrola alpina</i>				I					Kobanoichiyakusou
<i>Vitis flexuosa</i>				I					Sankakuzuru
<i>Ixeris dentata</i> var. <i>albiflora</i>				I					Shirobananigakusa
<i>Pyrola renifolia</i>				I					Ginyouichiyakusou
<i>Sorbus commixta</i>				I					Nanakamado
<i>Sambucus racemosa</i> ssp. <i>sieboldiana</i>				I					Niwatoko
<i>Acer japonicum</i>				I					Hauchiwakaede
<i>Botrychium x longistipitatum</i>				I					Hanawarabi
<i>Bromus rigidus</i>				I					Higenagasuzumenochahik
<i>Rumex acetosella</i>				I					Hmesuiba
<i>Carex oxyandra</i>				I					Himesuge
<i>Oenothera striata</i>				I					Mematsuyoigusa
<i>Rubus yabei</i>				I					Miyamaurajiroichigo
<i>Alnus firma</i>				I					Yasyabushi
<i>Stellaria aquatica</i>						I			Ushihakobe
<i>Paulownia tomentosa</i>						I			Kiri
<i>Ribes japonicum</i>						I			Komagatakesuguri
<i>Spiranthes sinensis</i> var. <i>amoena</i>						I			Nejibana

Table 2. continued

Species	Forests	Abandant ski slopes	Under gondola lines	Edges of ski slopes	Ski slopes	Open waterfronts	Forest waterfront s	cited in body text	Japanese name
<i>Lolium perenne</i>					I				Hosomugi
<i>Veronica japonensis</i>					I				Yamakugawata
<i>Persicaria pubescens</i>					I				Bontokutade
<i>Bistorta major</i> var. <i>japonica</i>						I			Ibukitoranoh
<i>Prunella vulgaris</i> ssp. <i>asiatica</i>						I			Utsubogusa
<i>Agrimonia japonica</i>						I			Kinmizuhiki
<i>Aletris foliata</i>						I			Nebarinogiran
<i>Lotus corniculatus</i> var. <i>japonicus</i>						I			Miyakogusa
<i>Fimbristylis subbispicata</i>						I			Yamai
<i>Fraxinus lanuginosa</i> f. <i>serrata</i>							I		Aodamo
<i>Swertia bimaculata</i>							I		Akebonosou
<i>Microstegium vimineum</i> var. <i>polystachyum</i>							I		Ashiboso
<i>Schizophragma hydrangeoides</i>							I		Iwagarami
<i>Diospyros kaki</i>							I		Kakinoki
<i>Rabdosia shikokiana</i> var. <i>lecantha</i> f. <i>kameba</i>							I		Kamebahikiokoshi
<i>Boehmeria gracilis</i>							I		Kusakoakaso
<i>Bistorta suffulta</i>							I		Kurinyukifude
<i>Senecio nikoensis</i>							I		Sawagiku
<i>Weigela decora</i>							I		Nishikiutsugi
<i>Arabis hirsuta</i>							I		Yamahatazao
<i>Clematis japonica</i>							I		Hansyoduru
<i>Arisaema serratum</i>							I		Mamushigusa
<i>Euonymus sieboldianus</i>							I		Mayumi
<i>Chrysosplenium ramosum</i>							I		Marubanekonome
<i>Clinopodium sachalinense</i>							I		Miyamatoubana
<i>Laportea bulbifera</i>							I		Mukagoirakusa
<i>Tricyrtis affinis</i>							I		Yamajinohotogisu
<i>Aconitum japonicum</i>							I		Yamatorikabuto
<i>Malus toringo</i>							I		Zumi

Roman numbers show frequency as follows: 0<I<20%, 20≤II<40%, 40≤III<60%, 60≤IV<80%, 80%≤V

Abbreviations: F: forest, ASS: abundant ski slopes, UGL: under gondola lines, ESS: edges of ski slopes, OW: open waterfronts, FW: forest waterfronts

Table 3. Mean and S.D. of canopy heights, canopy closures and diversities in each site type.

		Mean community heights (m)		Canopy closure (%)		Species diversity (H' bit)	
1	Forests	9.75 ± 0.61	a	77.9 ± 3.7	a	2.93 ± 0.83	a
2	Abandoned ski slopes	1.36 ± 0.31	b	35.8 ± 3.7	b, d	3.33 ± 0.53	b
3	Sites under gondola line	0.97 ± 0.38	c	56.0 ± 6.9	c	4.16 ± 0.54	c
4	Forest waterfronts	0.77 ± 0.08	c	77.5 ± 3.0	a	4.51 ± 0.39	d
5	Open waterfronts	0.74 ± 0.26	c,d	45.8 ± 3.9	c	3.79 ± 0.48	b, c
6	Edges of skislopes	0.74 ± 0.13	c	54.5 ± 8.8	d	3.96 ± 0.37	c
7	Ski slopes	0.41 ± 0.30	d	41.3 ± 8.2	d	3.26 ± 0.74	a

Different alphabets shows the significant differences among them (ANOVA, Fisher's PLSD, $p < 0.05$).