TYPES AND STRUCTURES OF GRASSLANDS IN THE SUBALPINE ZONE, CENTRAL JAPAN[1)]

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I. INTRODUCTION

1. Grassland in Japan

The islands of Japan are situated in latitude between 24° and 46°N and longitude between 122° and 148°E, and so under very wide range of climatic conditions, namely there are four principal climatic zones as folllows : subtropical, warm-temperate, cool-temperate and subarctic. One more climatic charact eristic is the high precipitation through the year (ca. 1,740mm in the mean annual precipitation). There are thus no arid regions in Japan. The climates mentioned above allow the developent of forests. According to the climatic zones, subtropical evergreen forest zone, warm-temperate evergreen forest zone, cool-temperate deciduous forest zone and subalpine/subarctic coniferous forest zone are recognized (Kira 1949).

Most of native grasslands of Japan are semi-natural grasslands, in the sense of Tansley (1939), except for a small area of alpine grassland, subalpine Altherbosa, etc. as truly natural communities in the same way as the climatic climax forests of Japan (Nakano 1944, Numata 1961). These semi-natural grasslands have been established under the influence of human activities such as logging, firing, mowing, trampling and grazing by domestic animals, and have developed as seral stages of secondary succession (Oseko 1937).

Numata (1969a) showed three grassland vegetation zones in Japan on a survey of all areas under mowing or grazing (Table 1). These zones correspond approximately to the climatic zones as follows : (A) subarctic, (B) cool- plus warm-temperate and (C) warm-temperate plus subtropical (Fig. 1). Grassland vegetation is mainly divided into mowing grasslands (meadows) and grazing grasslands (pastures), and in each grassland zone, some grassland types were physiognomically recognized : *Sasa* type and *Calamagrostis* type as meadow of A zone (Am), *Miscanthus* type (Bm), *Miscanthus* type and *Pleioblastus* type (Cm), *Poa* type and *Festuca* type as pasture of A zone (Ap), *Zoysia* type (Bp), and inland *Pleioblastus* type and coastal *Zoysia* type (Cp).

The classification of grassland vegetation in Japan was done at first by Oseko

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Table 1. Grassland vegetation zones in Japan based on a survey of all areas under mowing (meadow) or grazing (pasture). by Numata 1961

Grassland zone	Meadow	Pasture
A	*Sasa* type, *Calamagrostis* type (Am)	*Poa* type, *Festuca* type (Ap)
B	*Miscanthus* type (Bm)	*Zoysia* type (Bp)
C	*Miscanthus* type, *Pleioblastus* type (Cm)	Inland *Pleioblastus* type, Coastal *Zoysia* type (Cm)

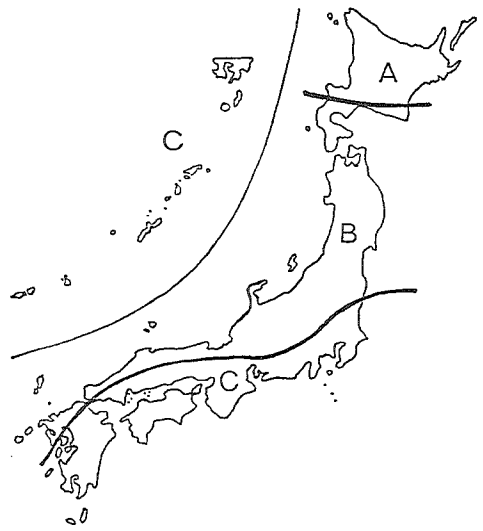

Fig. 1. The horizontal zones of grassland vegetation in Japan (see Table 1 for key). by M. Numata (1969a)

(1937), who divided it from the standpoint of dynamic ecology into *Miscanthus*–, *Imperata*–, *Zoysia*–, *Sasa*–, *Lespedeza*– and cryptogam–stages. After that, Nakano (1944), Yoshida (1950, 1956), Yoshioka (1955) and others also recognized the similar or other grassland types and stages. However the area of those studies was mainly limited to the north–eastern Japan in the cool–temperate region. Numata (1969a) surveyed the grassland vegetation from north to south in Japan, and suggested their successional and climatic relationships from the viewpoint of quantitative and dynamic ecology. Though there are many ecological studies on the grassland, there are few studies on the grassland in the subalpine zone and on the altitudinal distribution of grasslands.

2. Grasslands in the subalpine zone of Japan

The vertical (or altitudinal) vegetation zones on Japanese mountains have been generally distinguished as follows : (1) hilly zone, (2) montane zone, (3) subalpine zone and (4) alpine zone. The subalpine zone lies between 1,600 and 2,500m a. s. l. in Central Japan and between sea level and 1,500m a. s. l. in Hokkaido., and is characterized by evergreen coniferous forests of *Abies mariesii*, *A. veitchii* and *Tuga diversifolia* (in Central Japan), and *A. saccharinensis* and *Picea jezoensis* (in Hokkaido). Kira (1949) found that accumlated temperatures expressed as warmth index which showed a remarkably good correlation with the distribution of forest types. Table 2 summarizes the major forest zones as defined by the warmth index. According to

Table 2. Major forest zones as defined by the warmth and cold indices by Kira 1949

Forest zone	Warmth index (°C)	Cold index (°C)
Subtropical evergreen forest	>180	
Warm-temperate evergreen forest	85–180	>−10
(deciduous forest	85–180	<−10)
Cool-temperate deciduous forest	45– 85	
Subarctic/subalpine coniferous forest	15– 45	
Arctic/alpine meadow	<15	

this definition, the range of warmth index in the subalpine zone is between 15°C and 45°C. Today, the climax coniferous forests in the subalpine zone considerably remain as it is, because man's activities have hardly extended till the subalpine zone. Accordingly, most of semi-natural grasslands in Japan develop in lower altitudinal regions such as foot of mountains, hilly zone, montane zone, and flood plain, and there are few semi-natural grasslands in the subalpine zone.

The author looked for the semi-natural grasslands in the subalpine zone all over the country, but could not find out only several places, where concentrate mainly in the vicinity of Nagano Prefecture, Central Japan. Nagano Prefecture, so-called

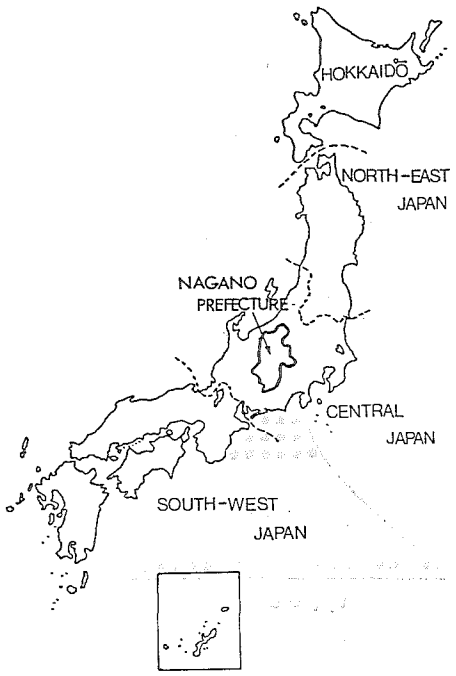

Fig. 2. The district names of Japan.

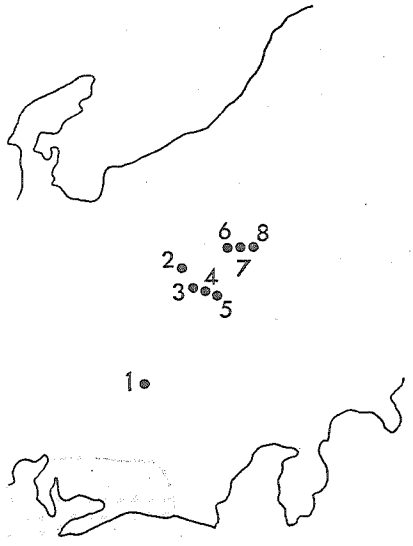

Fig. 3. Map of the study areas in Central Japan.
1. Fujimidai Heights 2. Utsukushigahara Heights 3. Hachibuse Heights 4. Kirigamine Heights 5. Ohgawara Pass 6. Yunomaru Heights 7. Takamine Heights 8. Yunotaira Heights

the roof of Japan, contains many plateaus and many mountains such as Northern Alps, Central Alps and Southern Alps, rising more than 2,500m above sea level. The author has surveyed hitherto many grasslands, except the *Sasa* type grassland, in the subalpine zone, Central Japan as followed : (1) Takamine Heights, (2) Yunomaru Heights, (3) Yunotaira Heights, (4) Utsukushigahara Heights, (5) Hachibuse Heights, (6) Kirigamine Heights, (7) Ohgawara Pass, (8) Fujimidai Heights (Fig. 2 & 3).

The Purposes of this study were to describe the grassland types in the subalpine zone, Central Japan, to elucidate the community structure such as species composition and biological spectrum. This study has been carried out since 1965.

II. STUDY AREAS AND THEIR ENVIRONMENTS

1. Location

The grasslands of eight localities were investigated. They contain pastures used for grazing, meadows used for mowing and abandoned grassland in the subalpine zone, Central Japan, and most grasslands develop in the summit of mountain or plateau (type A) and a few in the mountainside (type B) (Fig. 4).

(1) Takamine Heights (type A)

Takamine Heights (ca. 2,000m in altitude) originated in volcano is situated in the vicinity of Mt. Asama volcano (2,542m) and is covered by two type grassland communities which have been established by cutting every year for skiing field.

(2) Yunomaru Heights (type A)

The region is located at about 6 km westward from the Takamine Heights and has two high peaks, Mt. Eboshi (2,066m) and Mt. Yunomaru (2,103m). The grazing and abandoned grasslands occupy most of the area.

(3) Yunotaira Heights (type B)

Active volcano, Mt. Asama (2,542m) is situated in latitude 36°20'N and longitude 130°30'E. In its major eruption of 1783, the mountain gushed out tons of lava, which

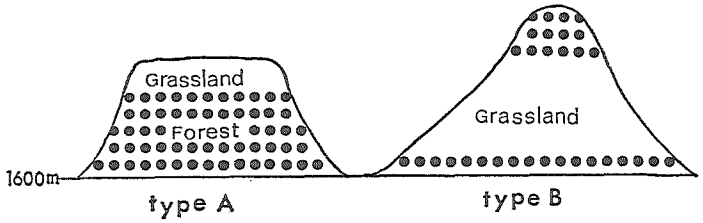

Fig. 4. Profile of the position of grasslands in the subalpine zone. Type A is situated in the summit of plateau or mountain and type B is situated in the side of a mountain.

formed lava plateau. The investigated area is a plateau, Yunotaira Heights (ca. 1,900–2,000m) where is located in the crater hillsside. Three grassland types (two : abandoned and one : grazing) extend in the region.

(4) Utsukushigahara Heights (type A)

This plateau is situated in latitude 36°15′N and longitude 138°10′E and extends from 1,800 to 2,000m in altitude and about 40km round. There are three grassland types such as pasture, meadow and abandoned grassland. Some ecological studies were carried out in this region.

(5) Hachibuse Heights (type A)

This region (1,800–1,900m) is located near the Utsukushigahara Heights and is narrow plateau (ca. 200ha). Most of all areas were used for grazing till 1974, but now it has been abandoned without biotic disturbance.

(6) Kirigamine Heights (type A)

The Kirigamine Heights lies 36°5′N latitude and 138°10′E longitude and is a lava plateau formed by volcanic eruption. the gently rolling plateau extends widely (ca. 3,000ha) and contains the heighest peak, Mt. Kurumayama (1,925m in altitude). Most areas of grassland, ranging from 1,600 to 1,900m have been abandoned for fifteen years after mowing.

(7) Ohgawara pass (type A and B)

This pass (2,100m) is situated between Mt. Tateshina (2,530m) and Mt. Futagodake (2,224m). The open grassland extends in the vicinity of this region. Two abandoned grassland types were found.

(8) Fujimidai Heights (type A)

The Fujimidai Heights lying in the boundary of Nagano Prefecture and Gifu Prefecture is located in the southernmost of mentioned above places. The Fujimidai pasture extends in the upper plateau (1,700–1,850m). This region is rainy in summer (see Fig. 7).

2. Climate

(1) General survey of Japanese climate

Japan is an arc of island surrounded the Pacific Ocean and the Sea of Japan and is located between the latitudes of 20°N and 46°N. Most of Japan belongs to the temperate zone and the distinction of four seasons is clear. The climate of Japan are influenced by the long islands of north to south, landforms, and monsoons and ocean currents. These factors caused many regional variations of the climate, namely six climatic regions (Fig. 5). In the region of the Pacific Coast Climate, the summers are hot and rainy, and the winters are dry. The sea of Japan Climate is characterized by much snow fall and not so cold in winter. The region of Nansei Islands Climate is warm and humid throughout the year. The Inland Sea Climate is warm and dry. The Central Heighlands Climate is marked with cool summer and cold

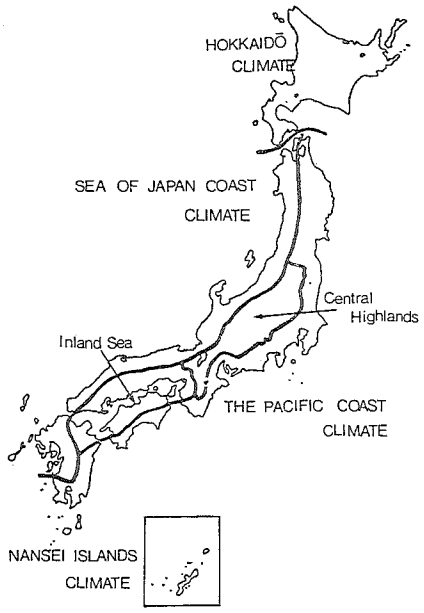

Fig. 5. Map showing the climatic regions in Japan.

winter, and light precipitation (Fig. 6 & 7). Most of study areas, except the Fujimidai Heights, belongs to the Central Heighlands Climate. On the horizontal climates of the Central Highlands, the north region shows the Sea of Japan Climate and the south region shows the Pacific Ocean Climate.

The central region shows the typical Central Highlands Climate. The altitudinal climates of the central region are divided into four zones: hilly (below 800 m above sea level), montane (800–1,600 m), subalpine (1,600–2,500m) and alpine (above 2,500m). These correspond with vertical or altitudinal forest zones (Suzuki 1961). Namely, the hilly zone extends

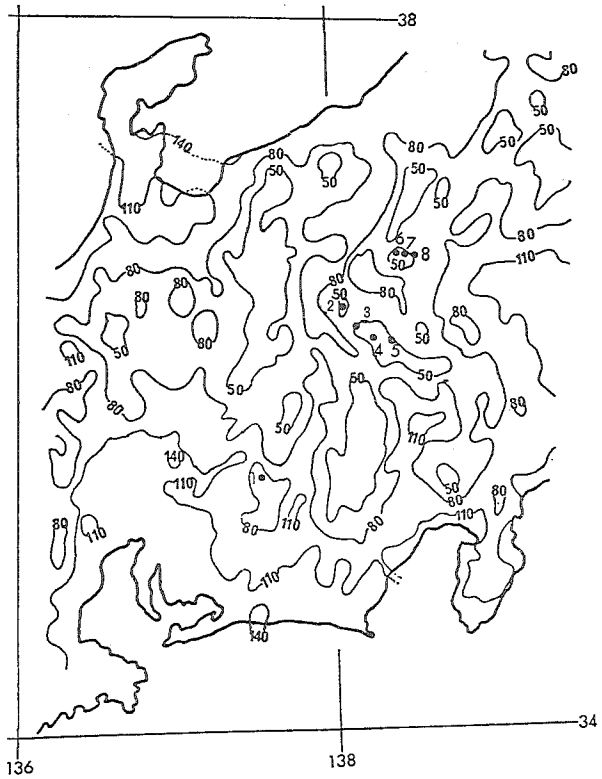

Fig. 6. Isotherm map showing the warmth indices for Central Japan.

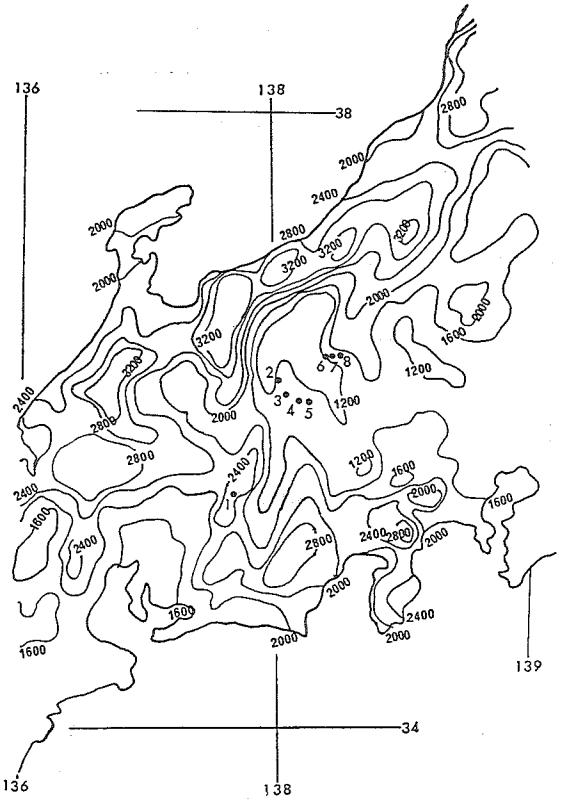

Fig. 7. Isohyet map showing the annual precipitation in Central Japan.

broad-leaved evergreen forest defined by above 85°C in the warmth index. The boundary between montane and subalpine zones corresponds generally to the 45°C, and the former contains the deciduous forest and the latter corresponds to the coniferous forest. The upper forest limit of the subalpine zone fits generally with the 15°C. The alpine zone coincides with *Pinus pumila* zone. The subalpine zone is covered generally by coniferous forests, ranging from 1,600m to 2,500m in altitude.

There are few climatic data on the study areas except on the Utsukushigahara and the Kirigamine Heights (Tables 3). According to the temperature data, the warmth index are 31.5°C and 35°C respectively. Most of the study areas show

Table 3. Monthly mean temperature (°C) at the Kirigamine Heights (1,925m) in 1944-1947 and the Utsukushigahara Heights (2,034m) in 1969.

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Noy.	Dec.	mean
Kirigamine Heights	-10.5	-10.7	-6.3	0.9	5.8	11.3	14.4	15.7	11.6	6.3	0.5	-8.6	2.5
Utsukushigahara Heights	-8.8	-7.1	-4.6	1.1	7.7	9.6	13.2	14.6	10.8	4.2	-1.1	-7.3	2.7

rather low annual precipitation (1,000–1,600mm), but only the Fujimidai Heights show high annual precipitation (more than 2,400mm). On the whole, the study areas have cool summer and cold winter, and dry or humid habitat.

3. Soils

All the study areas exist in the volcanic mountains. These volcanoes ejected so large volume of ash and lava over the mountains that they strongly influenced the property and composition of the soils. Most of the study areas are covered by black soils. The typical black soils derived from volcanic ash and they support the grassland or the red pine forest vegetation with lower productivity. In general, the black soils are very compact, wet, lacking in porosity, and showing a high phosphorus requirment. The soil surveys were carried out only at special areas.

III. METHODS

The grassland can be classified into various categories based on differrent viewpoints (Numata 1969a). Grasslands in an agricultural sense based on a kind of biotic facters are divided into semi-natural meadow (mowing grassland), pasture (grazing grassland), abandoned (old) field, man-made grassland, etc. The study of grasslands was based on this sense. Studies regarding types and structures of grasslands in the subalpine zone, Central Japan were carried out from 1965 to 1975.

Nineteen stands in eight areas were investigated. In each grassland, most homogenous stands were selected. In each stand ten 0.5×0.5m quadrats or ten 1×1m quadrats as usual were set out for sampling vagetation. The cover and plant height were measured on the species occuring in each quadrat. The summed dominance ratio (Numata 1966a) based on the cover and plant height (SDR_2) was calculated using the former data, and the biological spectra based on the combination of life-forms (Numata & Asano 1969) were studied.

IV. RESULTS

The studied grasslands were classified into pastures, meadows and abandoned grasslands.

1. Grassland type, species composition and biological spectrum of pastures

There were four pastures in the subalpine zone of Central Japan; namely, (1) Fujimidai pasture, (2) Hachibuse pasture, (3) Utsukushigahara pasture and (4) Yunomaru pasture and five stands were investigated. The species compositions of these stands were shown in Table 4.

In the Fujimidai pasture two types were found (Tsuchida 1976). The community (stand 1) dominated by *Festuca ovina* occurs in the dry ridge with prominent species,

Table 4. Floristic composition of each stand (1–5) according to SDR (%) in pastures. Stands 1 and 2 : Fujimidai Heights 3 : Hachibuse Heights 4 : Utsukushigahara Heights 5 : Yunomaru Heights
r : rosette type

Stand number	1	2	3	4	5
Date investigated	'72. 07. 23	'72. 07. 23	'72. 09. 11	'68. 08. 17	'74. 08. 20
Altitude (m)	1,730	1,720	1,880	1,950	1,900
Ground cover (%)	60. 0	84. 3	88. 5	88. 0	85. 8
Number of species	7	6	36	42	39
Festuca ovina	100. 0	62. 8	70. 2	87. 6	100. 0
Carex oxyandra	56. 0	71. 3	15. 4	52. 0	9. 3
Agrostis clavata	34. 1	67. 6	5. 5	57. 2	18. 5
Maianthemum dilatatum	12. 8				
Athyrium yokoscense	3. 8		3. 7		
Struthiopteris niponica	1. 6				
Plantago asiatica	0. 9			4. 3	15. 9
Scabiosa japonica			53. 6	75. 2	
Carex nanella			50. 1	12. 8	1. 5
Hosta albomarginata			2. 3		
Scabiasa japonica (r)			68. 4		
Calamagrostis longiseta			22. 6	51. 4	
Arundinella hirta			24. 6		71. 0
Hemerocallis dumortieri var. esculenta			27. 7	4. 7	
Juncus tenuis		40. 6		5. 2	
Disporum smilacinum			5. 1		
Carex nervata			19. 5	17. 2	45. 5
Lilium leichtlinii var. tigrinum			4. 6		
Vaccinium vitis-idaea			8. 4	42. 3	
Parnassia paeustris			12. 5	30. 0	
Geranium yesoense var. nipponicum			5. 9	54. 2	26. 7
Halenia corniculata			9. 6	38. 6	
Solidago virga-aurea var. asiatica			14. 4	23. 8	5. 1
Adenophora triphylla var. japonica			5. 4		6. 8
Astilbe thunbergii			7. 8	4. 7	1. 8
Ixeris dentata		5. 2		4. 7	39. 6
Vaccinium hirtum			1. 2		
Sanguisorba officinalis			1. 5		18. 7
Potentilla freyniana			5. 7		19. 5
Polytrichum juniperinum			0. 6		
Dryopteris austriaca			0. 7		
Solidago virga-aurea var. asiatica(r)			2. 4		

Cirsium japonicum			3.1	12.4	7.0
Cirsium japonicum(r)			3.1		
Veratrum maackii var. japonicum			3.4		2.5
Hypericum erectum			6.0	16.0	15.2
Rhododendron japonicum			2.7		7.3
Bryhnia novae-angliae			0.2		
Adenophora triphylla var. japonica(r)			0.9		
Moehringia lateriflora			1.1	22.9	2.3
Thelypteris phegopteris			1.0	14.3	
Fragaria nipponica				46.7	
Sasa senanensis				41.3	10.4
Veronica onoei				35.2	
Anaphalis margaritacea var. angustior		2.3		34.4	
Lycopodium obscurum				28.6	
Allium splendens				27.1	
Trifolium repens				26.6	11.8
Poa pratensis				23.4	16.7
Polygonum cuspidatum				22.9	
Agrostis flaccida				19.1	
Angelica decursiva				16.0	
Rubus yabei				14.3	
Luzula multiflora				12.8	
Euphrasia maximowiczii				8.9	
Gentiana makinoi				8.9	
Polygonum bistorta				6.2	
Aquilegia buergeriana				5.2	
Rubus koehneanus				4.7	39.6
Viola patrinii				4.3	
Heloniopsis orientalis				3.6	
Polytrichum commune				42.9	
Viola grypoceras					1.2
Ranunculus japonicus					2.6
Cirsium tanakae					38.5
Coptis trifolia					1.7
Trifolium lupinaster					27.3
Veronica onoei					20.0
Thymus japonicus					16.3
Filipendula multijuga var. ciliata					8.5
Sceptridium ternatum					0.8
Prunella asiatica var. lilacina					5.6
Miscanthus sinensis					14.1
Salix reinii					13.7

Erigeron canadensis					2.7
Libanotis coreana					1.2
Leontopodium japonicum					1.7

Carex oxyandra and *Agrostis clavata*. While, the community (stand 2) dominated by *Carex oxyandra* occurs in the moist and mesic place with *Agrostis clavata*, *Festuca ovina* and *Juncus tenuis*. These two communities are floristically very poor. In the Hachibuse pasture, *Festuca ovina–Scabiosa japanica* community (stand 3) occurs in the ridge. The dry species, *Carex nanella* is also more prominent than *Carex oxyandra*. This community is floristically richer and has characteristic species such as *Scabiosa japonica* which is unfavorable plant for livestock and *Carex nanella* which occurs in the dry habitat. The grazing grassland (stand 4) of the Utsukushigahara Heights is also dominated by *Festuca ovina* and is floristically richer (Tsuchida 1973). Other prominent species are *Scabiosa japonica*, *Agrostis clavata*, *Geranium yesoense* var. *nipponicum* and *Carex oxyandra*. This community is considerable heavy grazing grassland and occurs in the dry places. In the grazing grassland (stand 5) of the Yunomaru Heights, *Festuca ovina* community occurs in large areas and is also floristically richer. Prominent species are *Festuca ovina*, *Aruundiinella hirta*, *Carex nervata*, *Rubus koehneanus* and *Circium tanakae*. The characteristics of this community have *Arundinella hirta* with high dominance (71.0% in SDR) and some shrubs such as *Rhododendron japonicum*, *Rubus koehneanus* and *Salix reinii*.

These five stands have only three common species which are *Festuca ovina*, *Carex oxyandra* and *Agrostis clavata*, and *Festuca ovina* dominates exclusive of stand 2 of the Fujimidai pasture which is moist type. Eventually, the grazing grasslands in the subalpine zone may be called the *Festuca ovina* type grassland or the *Festuca–Carex* type grassland based on the dominants.

The biological spectrum of each stand is shown in Fig. 8. In the dormancy form*1, the rate of H is high in almost all the communities or hypogeal (H + G) occupies mostly. This relatively high in SDR % in stand 3 (Hachibuse pasture) and epigeal (Ph+Ch) is slightly higher in stand 5 (Yunomaru pasture) than in others. Stands 1 and 2 in the Fujimidai pasture show the very simple composition (only H and G). In the disseminule form*2, D_1 and D_4 are prominent (more than 80%) and D_1 in SDR % dominates in stands 1 and 2 (Fujimidai pasture) and stand 5 (Yunomaru pasture), and D_4 dominates in stand 3 (Hachibuse pasture). In the radicoid form*3,

*1. Megaphanerophytes (MM), mesophanerophytes (MM), microphanerophytes (M), nanophanerophytes (N), chamaephytes (Ch), hemicryptophytes (H), geophytes (G), and therophytes (Th).

*2. D_1 (anemochore and hydrochore), D_2 (zoochore), D_3 (autochore), D_4 (bolochore), and D_5 (only vegetative propagation).

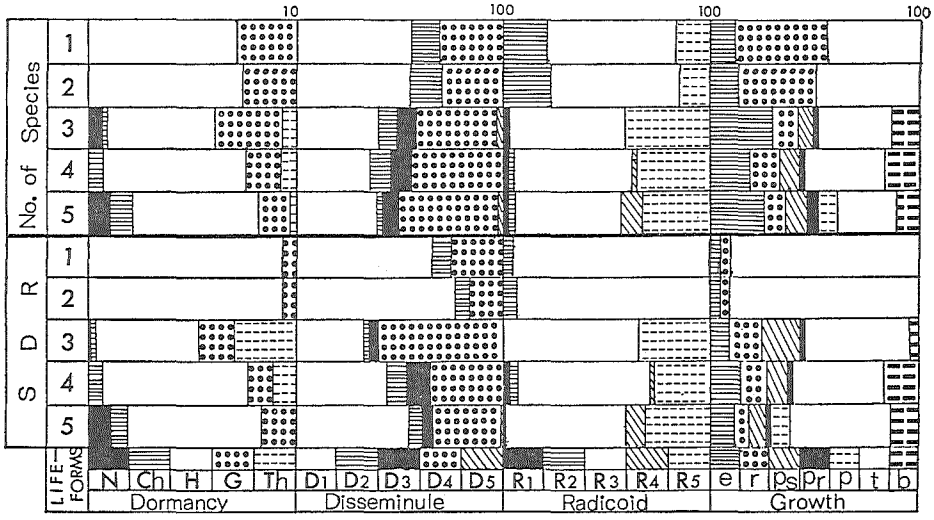

Fig. 8. Biological spectra based on the number of species (Sp%) and on SDR (SDR %) in pastures (stands 1–5).

R_3 prevails at all stands and R_5 is slightly high in stands 3, 4 and 5. In the growth form*4, t dominates at all stands especially stnds 1 and 2 and other forms occupy the remains. In Sp%, e is relatively high but in SDR % it is low. The rosette type (r+pr+ps) having rosette period shows relatively high rate, too. Thus the dominant biological types of the *Festuca ovina* type grassland are HD_1 or D_4R_2t.

2. Grassland type, species composition and biological spectrum of meadows

There were only two meadows used for mowing in the subalpine zone, Central Japan as follows : the Utsukushigahara meadow (stand 6) and the Takamine meadow (stands 7 and 8).

Species composition of three stands are shown in Table 5. Stand 6 (Utsukushigahara Heights) is floristically richer and is characterized by high dominance of *Calamagrostis longiseta*. Other prominent plants are *Circium japonicum* and *Scabiosa japonica*. This community is cut every year and occurs in the dry ridge. In the low layer of community, *Carex* spp., *Geranium yesoense* var. *nipponicum* and *Trifolium lupinaster* are prominent. Stand 7 of the Takamine meadow is also floristically richer. *Calamagrostis longiseta* has a high dominance (89.0%) and *Sasa nana*, too (75.4%). Other species have low dominance. This community occurs in the upper slope and the ridge top, and is cut for skiing every year. Stand 8 is characterized

*3. R_{1-3} (rhizomatous plants with long (R_1), intermediate (R_2) and short (R_3) rhizomes, R_4 (stoloniferous), and R_5 (non-clonal growth : monophyte).

*4. Erect (e), partial rosette (pr), pseud-rosette (ps), prostrate (p), tussock (t), branched (b), rosette (r), liana (l) and spiny (sp).

Table 5. Floristic composition of each stand (6–8) according to SDR (%) in meadows. Stand 6 : Utsukushigahara Heights 7&8 : Takamine Heights
r: rosette type

Stand number	6	7	8
Date investigated	'72. 08. 10	'74. 08. 18	'74. 08. 19
Altitude (m)	1,910	1,970	1,950
Ground cover (%)	95. 3	97. 5	100. 0
Number of species	45	39	5
Calamagrostis longiseta	100. 0	89. 0	
Cirsium japonicum	65. 1	6. 1	
Scabiosa japonica	64. 8		
Bupleurum longiradiatum subsp. sachalinense var. elatius	55. 3		
Polygonum cuspidatum	49. 0		
Carex nanella	48. 6		
Solidago virga-aurea var. asiatica	47. 7	31. 5	
Geranium yesoense var. nipponicum	47. 1	6. 2	
Trifolium lupinaster	43. 8	12. 5	
Adenophora triphylla var. japonica	42. 1	10. 2	
Potentilla freyniana	40. 8		
Sasa senanensis	40. 2		
Sasa nana		75. 4	73. 8
Carex nervata	40. 2		
Artemisia princeps	40. 1		
Libanotis coreana	39. 0	9. 3	
Moehringia lateriflora	36. 4		
Athyrium yokoscense	34. 9		
Veratrum maackii var. japonicum	34. 1		
Achillea alpina	32. 3		
Aquilegia buergeriana	27. 7		
Ranunculus japonicus	27. 1	2. 2	
Anaphalis margaritacea var. angustior	24. 4	1. 9	
Festuca ovina	22. 9	0. 7	
Dianthus superbus	22. 6		
Viola patrinii	22. 2		
Picris japonica	21. 6		
Astilbe thunbergii	20. 2		
Rubus koehneanus	20. 5		
Convallaria keiskei	19. 2		
Rhododendron japonicum	17. 0	9. 0	
Leontopodium japonicum	17. 0		
Thelypteris phegopteris	16. 4		
Sedum aizoon	16. 4		
Senecio flammeus var. glabrifolius	14. 6		
Calamagrostis hakonensis	14. 6		
Vaccinium vitis-idaea	14. 3	15. 6	

Angelica decursiva	13.1		
Euphrasia maximowiczii	11.9		
Luzula multiflora	11.6	3.0	
Carex oxyandra	7.8		
Plantago asiatica	7.5		
Halenia corniculata	4.0	2.4	
Gymnadenia conopsea	3.8		
Lycopodium obscurum	3.8		
Polytrichum commune	7.2		
Filipendula multijuga var. ciliata		3.5	
Sanguisorba officinalis		11.8	
Shortia soldanelloides		13.3	
Trientaeis europaea		15.7	
Maianthemum bifolium var. dilatatum		9.6	
Hypericum erectum		12.4	17.5
Coptis trifolia		5.9	
Polygonum bistorta		5.7	
Ligularia dentata		17.1	
Cirsium japonicum(r)		2.7	
Arundinella hirta		22.3	
Veratrum maackii var. parviflorum		9.7	
Salix reinii		2.4	
Epilobium angustifolium		3.7	3.7
Vaccinium smallii		19.2	
Calamagrostis langsdorffii		5.2	96.1
Aletris foliata		3.2	
Anemone debilis		2.8	
Gauetheria miqueliana		2.9	
Betula ermanii		3.3	
Angelica polymorpha		5.0	
Hieracium umbellatum		5.1	
Thalictrum aquilegifolium var. intermedium		2.0	
Serratula insularis		2.5	
Tripetaleia bracteata		1.1	

by small number of species (5) and by strong dominance of *Calamagrostis langsdorffii* in the high layer of community and of *Sasa nana* in the low layer. This community is found on the lower slope and the concavity that are snowy in winter. They are maintained with occasionally cutting. The *Calamagrostis longiseta* commuity occurs in the drier habitat and the *C. langsdorffii* community occurs in the moist habitat. *Sasa* spp. are important species in these communities, but they reduce by cutting. If these communities are abandoned, they will gradually progress to the *Sasa* spp. communities (Tsuchida 1973a, 1976a, 1979).

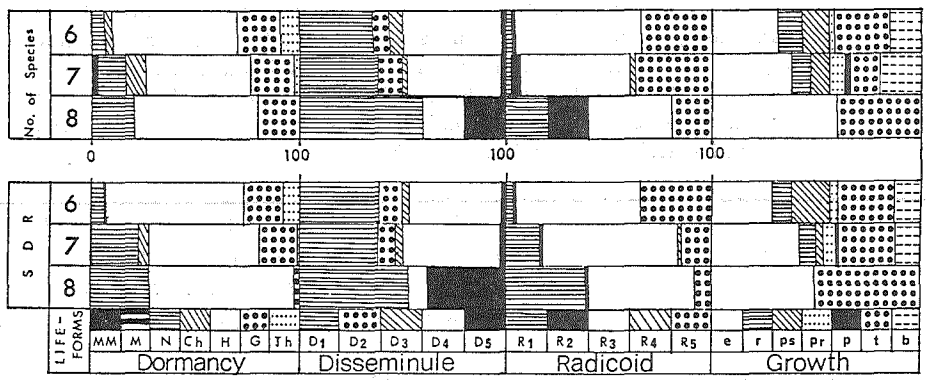

Fig. 9. Biological spectra based on the number of species (Sp%) and on SDR (SDR%) in meadows (stands 6–8).

The Biological spectrum of each stand is shown in Fig. 9. In the dormancy form, H is very prominent in both of Sp% and SDR% at all stands. The epigeal (Ph+Ch) is relatively high at stands 7 and 8 (Takamine Heights), and at stand 6 (Utsukushigahara Heights). This reason is owing to the occasional cutting: the Utsukushigahara meadow and the Takamine meadow are cutted every other year. In the disseminule form, the rate of D_4 is slightly higher than that of D_1 at stands 6 and 7, but the relationship of $D_1 > D_5 > D_4$ is observed at stand 7. In the radicoid form, R_3 dominates at all stands. The high rate of R_1 at stand 7 is due to the dominance of *Sasa*. In the growth form, e is prominent at all stands and t in SDR% is considerably prominent, too. In stands 6 and 7, the rosette types (r, ps and pr) which occur in low layer of community show relatively high rate. Stand 8 shows very simple composition of growth form (only e and t) owing to the dense cover of *Calamagrostis langsdorffii* and *Sasa nana*. Thus, the dominant biological types of these meadows are HD_4R_3e or t.

3. Grassland type, species composition and biological spectrum of abandoned grasslands

Eleven stands (9–19) were surveyed in the abandoned grasslands of subalpin zone. These grassland communities were once grazed (stands 11 and 16), mowed or burnt (other stands). The abandoned time is difference in each stand.

(1) Species composition of each stand (Table 6)

Stand 9 is dominated by *Calamagrostis longiseta* and *Sasa senanesis* (100% and 76.3% in SDR), with about 30% in SDR each for *Solidago vigra-aurea* var. *asiatica* and *Geranium yesoense* var. *nipponicum*. This commuity is found the relatively dry and open ridge in the Ohgawara Pass. Stand 10 is floristically richer (51 species) and *Sasa nana* (86.1% in SDR) dominates. Other prominent species are *Calamagrostis longiseta* (64.4%), *Hemerocallis dumortieri* var. *esculenta* (45.4%), *Arundinella hirta*

Table 6. Floristic composition of each stand (9–19) according to SDR (%) in abandoned grasslands. Stand 9 : Ohgawara Pass 10 : Kirigamine Heights 11 : Hachibuse Heights 12 : Utsukushigahara Heights 13 : Yunotaira Heights 14 : Mt. Eboshi in the Yunomaru Heights 15 : Yunomaru Heights 16 : Fujimidai Heights 17 : Ohgawara Pass 18 : Kirigamine Heights 19 : Yunotaira Heights r: rosette type

Stand number	9	10	11	12	13	14	15	16	17	18	19
Date investigated	1974	1976	1974	1971	1976	1974	1974	1972	1974	1976	1976
	08. 24	07. 28	07. 23	08. 26	08. 18	08. 21	08. 20	07. 24	08. 23	07. 29	08. 18
Altitude (m)	2,100	1,880	1,890	1,900	2,000	2,050	2,000	1,750	2,200	1,900	1,950
Ground cover (%)	93. 5	90. 0	91. 3	92. 5	89. 6	85. 5	90. 3	93. 5	90. 7	93. 8	95. 3
Number of species	26	51	30	25	28	48	39	8	16	35	13
Solidago virga-aurea var. asiatica	31. 7	39. 5	13. 7	41. 6	22. 6	23. 4	29. 7	4. 4	34. 2	8. 4	
Sasa senanensis	76. 3		5. 5	38. 4					73. 1		
Calamagrostis longiseta	100. 0	64. 4	64. 0	85. 4	91. 3	100. 0	96. 0			8. 0	12. 9
Calamagrostis langsdorffii	24. 5							100. 0	99. 0	85. 9	83. 8
Lingularia dentata	27. 1				4. 0		11. 7				
Gaultheria miqueliana	16. 0						11. 1				
Solidago virga-aurea var. asiatica	13. 9		2. 4			15. 4	17. 7		13. 1		
Geranium yesoense var. nipponicum	31. 1	33. 6	70. 8		31. 8	21. 1	10. 8		12. 9	5. 7	23. 7
Vaccinium vitis-idaea	15. 9		11. 7	1. 5		27. 0	31. 6		16. 8		
Coptis trifolia	0. 8					2. 0	4. 6		8. 1		
Potentilla freyniana	6. 8	7. 5	12. 2	4. 7	7. 6	9. 1					
Carex oxyandra	11. 7		67. 1	17. 3		11. 5	14. 0	59. 0	53. 8		
Thelypteris phegopteris	6. 8		20. 0			4. 3			3. 0	7. 6	
Gentiana scabra var. buergeri	4. 1						2. 2		4. 9		
Epilobium angustifolium	1. 1									34. 1	
Scabiosa japonica(r)	9. 1	11. 0	5. 7	13. 2		7. 4	1. 4				
Moehringia lateriflora	1. 8		6. 8	9. 8		4. 9			8. 3	1. 6	
Scabiosa japonica	14. 1	15. 1	10. 8	33. 5	10. 8	6. 5	4. 1				
Malus sieboldii	6. 2										
Anaphalis margaritacea var. angustior	9. 4	2. 5	3. 6	31. 3		3. 8	3. 1				5. 0
Parnassia palustris	2. 3	4. 8		3. 2	2. 7	8. 8					
Maianthemum dilatatum	0. 5					2. 3	4. 7	25. 4	20. 2	4. 0	
Hypericum erectum	3. 4	1. 1	16. 4	15. 3	3. 2	9. 0	16. 3			3. 7	
Selaginella tamariscina	1. 2										
Sasa nana		86. 1				68. 9	71. 0			45. 7	76. 7
Hemerocallis dumortieri var. esculenta		45. 4	100. 0	2. 0	22. 6						
Arundinella hirta		44. 6	5. 6		22. 5	40. 0			1. 1		
Miscanthus sinensis		44. 4		5. 5		30. 2					

Carex nervata	39.4			21.1					
Allium splendens	35.2								
Adenophora triphylla var. japonica	34.4	24.1	51.6	34.0	15.2				22.9
Aster scaber	31.7								
Sanguisorba officinalis	29.8	30.0		28.2	27.3				
Veratrum maackii var. japonicum	28.3	16.0		8.2	7.4			1.0	
Angelica decursiva	27.0								
Hosta sieboldiana	25.9								
Ixeris dentata	25.0					9.4	0.6		
Vicia unijuga	23.0								11.0
Potentilla fragarioides var. major	22.0								
Euphorbia adenochlora	20.0								
Ranunculus japonicus	19.6								
Cirsium japonicum	19.0		37.0	61.9	41.9	18.8			
Atractylodes japonica	18.9			37.0					
Disporum smilacinum	17.6								
Pedicularis resupinata	16.9			4.9		1.2		21.5	
Synurus excelsus	16.6							3.0	
Polygonum bistorta	16.5	22.1		7.9				8.3	
Cirsium tanakae	15.2				32.6				
Deinanthe bifida	10.4							1.3	
Viola hirtipes	9.3								
Calamagrostis hakonensis	8.6							22.0	
Carex siderosticta	8.3							0.8	
Dianthus superbus	8.1		4.1		3.0				
Euphrasia maximowiczii	5.8			4.5		1.5			
Heloniopsis orientalis	5.2								
Leontopodium japonicum	5.1				28.3	19.3			
Saussurea insularis	4.1								
Carex nanella	3.5	15.3	41.2	41.2	21.5	1.5		2.4	
Halenia corniculata	3.2					10.8			
Festuca ovina	2.3	38.9			2.1	16.7	14.7		
Gymnadenia conopsea	2.2	6.5							
Aletris foliata	2.0				4.0	4.3			
Viola patrinii	1.8								
Rubus koehneanus	1.4					5.3			
Senecio flammeus var. glabrifolius	0.9	4.7	15.2		3.2				
Sceptridium ternatum	0.9								
Polygonum cuspidatum		26.6		31.3	8.0	10.7	2.9	2.5	12.1
Astilbe thunbergii		24.9							
Vaccinium smallii var. glabrum		4.4							

var. glabrum			4.4								
Rhododendron japonicum			13.0	69.6		23.3					
Agrostis clavata			2.8					6.7			
Tulotis ussuriensis			3.5								
Polytrichum juniperinum			0.6								
Trifolium lupinaster				32.0	21.9	6.2					2.7
Cirsium japonicum(r)				1.9	20.5	15.7	15.6				
Thalictrum aquilegifolium										15.3	
var. intermedium					18.8						
Polygonatum odoratum											
var. pluriflorum					11.4						
Luzula plumosa					10.7						
Deschampsia flexuosa					8.9						
Conioselinum filicinum					8.4						
Artemisia princeps					7.9	11.3	34.3				
Convallaria keiskei				21.9	6.1	18.8	1.3				
Cirsium tanakae						14.6					
Athyrium yokoscense						2.9					
Synurus pungens(r)						19.6					
Shortia soldanelloides						20.9	18.5				
Veratrum maackii											
var. parviflorum						13.7	13.7				
Viola grypoceras						15.5					
Luzula multiflora						7.6	1.1				
Aquilegia buergeriana						1.2					
Achillea alpina var. discoidea				9.9		6.3					
Synurus pungens						9.6					
Synurus pungens						9.6					
Libanotis coreana						1.3	28.3				
Angelica pubescens										21.8	
Trientalis europaea				2.0			12.7				
Lycopodium clavatum							12.0				
Cornus canadensis							4.4				
Linnaea borealis							0.6				
Sasaella sasaelloides								33.5			
Prenanthes acerifolia								6.7			
Lycopodium obscurum									4.3		
Carex brunnescens									1.8		
Aralia cordata										80.2	
Aster glehnii var. hondoensis										78.0	
Rodgersia podophylla										75.0	
Artemisia montana										61.3	58.5
Cacalia hastata											
var. farfaraefolia										56.5	
Veronicastrum sibiricum											
var. japonicum										28.5	7.0

Cimicifuga simplex										26.3	
Senecio cannabifolius										20.9	
Ligularia stenocephala										18.9	
Ainsliaea acerifolia var. subapoda										18.4	
Athyrium vidalii										10.7	
Galium kamtschaticum var. acutifolium										1.7	
Trillium tschonoskii										0.9	
Serratula insularis											25.8
Angelica polymorpha											12.5
Lilium leichtlinii var. tigrinum				3.1							
Bupleurum longiradiatum sub-sp. sachalinense var. elatius				2.9							

(44.6%) and *Miscanthus sinensis* (44.4%). This community was abandoned about fifteen years ago and occurs in the higher elevations or the dry ridge of the Kirigamine Heights. Stand 11 is characterized by *Hemerocallis dumortieri* var. *esculenta* with high dominance (100% in SDR) and some subdominant species such as *Geranium yesoense* var. *nipponicum* (70.8%), *Carex oxyandra* (67.1%) and *Calamagrostis longiseta* (64.4%). *Festuca ovina* has slightly high SDR (38.9%). This community was used for grazing before few years. Therefor, *Carex* spp. and *Festuca ovina* which dominate in the grazing grassland occur with rather high dominance. This community occurs also in the ridge top of the Hachibuse Heights. Stand 12 is dominated by *Calamagrostis longiseta*, *Rhododendron japonicum* and *Adenophora triphylla* var. *japonica*. *Carex nanella* is dominant in the low layer of community. This community has been abandoned for a long time after cutting and the shrub *Rhododendron japonicum* is increasing, and occurs in the most of abandoned grassland in the Utsukushigahara Heights (Shimizu et al. 1971). Stand 13 is characterized by strong dominace of *Calamagrosits longiseta* and *Cirsium japonicum*. This community was found in the stable places such as gentle slopes or level places of the Yunotaira Heights. As another characteristic, *Sasa* sp. is not lacking due to poor volcanic soils. Stand 14 was taken up at the summit of Mt. Ebosshi (2,066m), Yunomaru Heights and is characterized by high dominance of *Calamagrostis longiseta* and *Sasa nana*. This community occurs in the wind-swept aind xeric southern slopes of Mt. Eboshi. *Arundnella hirta* and *Miscanthus sinensis* as the dominants of *Miscanthus* type grassland are relatively prominent (40.0 and 30.2 in SDR% respectively). This was established by cutting for a long time but now has been abandoneed. Stand 15 was set out at the other xeric southern slopes on the Yunomaru Heights *Calamagrostis longiseta* and *Sasa nana* are dominants (96.0% and 71.0% respectively) and other species

have low dominance (below 34.3% in *Artemisia princeps*). This community was also abandoned after mowing. Stand 15 a moist grassland community of the Fujimidai Heights and is floristically very poor community. This community is dominated by *Calamagrostis langsdorffii* (100%) in the high layer of community and *Carex oxyardna* (59.0%) in the low layer and occurs in the abandoned place after grazing. stand 17 is also a mesic grassland community in the level place of the Ohgawara Pass. This community is also floristically poor and is dominated by *Calamagrostis langsdorffii* (99.0%), *Sasa senanensis* (73.1%) and *Carex oxyandra* (53.5%). This place was used for mowing. Stand 18 is characterized by the dominance of tall grasses and herbs such as *Calamagrostis langsdorffii* (85.9%), *Aralia cordata* (80.2%), *Aster glehni* var. *hondoensis* (78.0%), *Rodgersia podophylla* (75.0%) and so on. This community occurs in the snowy, northern slopes of high elevation in the Kirigamine Heights and was abandoned after mowing. Stand 19 was set out at the subalpine moist grassland in the Yunotaira Heights, Mt. Asama. This community is characterized by relatively few species and the dominance of *Calamagrostis langsdorffii* (83.8%), *Sasa nana* (76.7%) and *Artemisia montana* (58.8%), and occurs in the snowy slopes of subalpine zone. This is also abandoned grassland after mowing.

(2) Biological spectrum of each stand

The biological spectrum of each stand (9–19) is shown in Figs. 10 & 11. In the dormancy form, the relationship of hypogeal (H + G) > epigeal (Ph + Ch) > Th is observed at all stands. In the abandoned grasslands for relatively long time such as

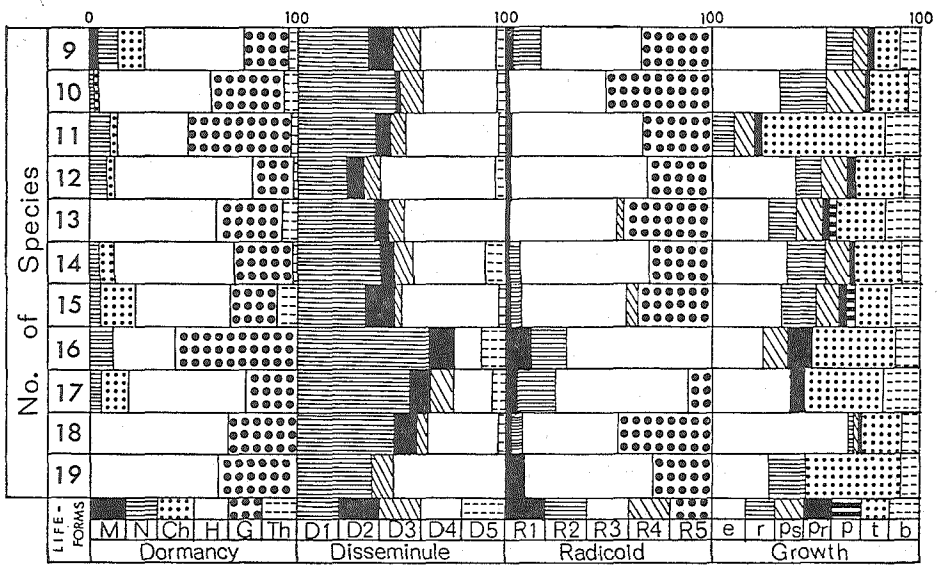

Fig. 10. Biological spectra based on the number of species (Sp%) in abandoned grasslands (stands 9–19).

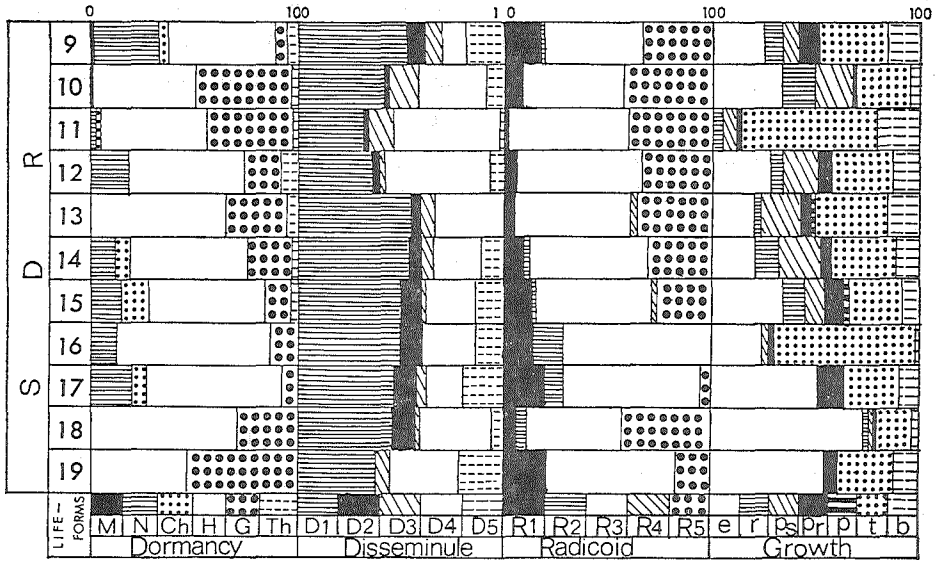

Fig. 11. Biological spectra based on the SDR (SDR%) in abandoned grasslands (stands 9–19).

stands 9 (Ohgawara Pass), 14 (Mt. Eboshi in the Yunomaru Heights), 15 (Yunomaru Heights) and 17 (Mt. Futagodake in the Ohgawara Pass), the rate of Ph is relatively high (15–30 in both Sp % and SDR %). H dominates at all stands, except at stand 16 (Fujimidai Heights) which G dominates in Sp%. In the disseminule form, D_1 or D_4 show high rate at each stand. The stands 9, 10 and 11 showing high rate of D_4 and low rate of D_1 in SDR% are the grasslands which were abandoned ralatively in recent years. While, other stands showing high rate of D_1 and low rate of D_4 in SDR% are the grasslands which have been abandoned for long years. The latter shows also higer rate D_5 than the former. In the radicoid form, R_3 and R_5 dominate at all stands, but in stands 16, 17 and 18, the rate of R_5 is low. This reason is considered that these communities are floristically very poor with much dense cover of *Calamagrostis langsdorffii*. In the growth form, e or t dominates at all stands, and the rate of rosette types (r+ps+pr) in SDR% is relatively high at stands 9-15, but stands 16–19 show low rates of r+ps+pr. This reason is the same as the preceding, too. Through the biological spectra of the abandoned grasslands, the dominant biological types are considered as HD_1 or D_4R_3e or t.

V. DISCUSSION

1. Grassland types and structures

The grassland types recognized in the subalpine zone, Central Japan are as

follows: *Festuca ovina* type as grazing grasslands, *Calamagrostis longiseta* type or *C. langsdorffii* type as mowing grasslands, and *Calamagrostis longiseta–Sasa* spp. type, *C. langsdorffii* type or other types as abandoned grasslands. *Festuca ovina* type pastures occur in the dry place such as the top of the mountain and the ridge top in the subalpine zone. *Calamagrostis longiseta* type meadows occur also in the dry place as the preceding. *Calamagrostis langsdorffii* type meadows are found in the humid places such as snowy or rainy places in the subalpine zone, *Calamagrostis longiseta–Sasa* spp. type and *C. langscorffii* abandoned grasslands occur in the dry and humid areas respectively. The relationships among these community types are shown in Fig. 12.

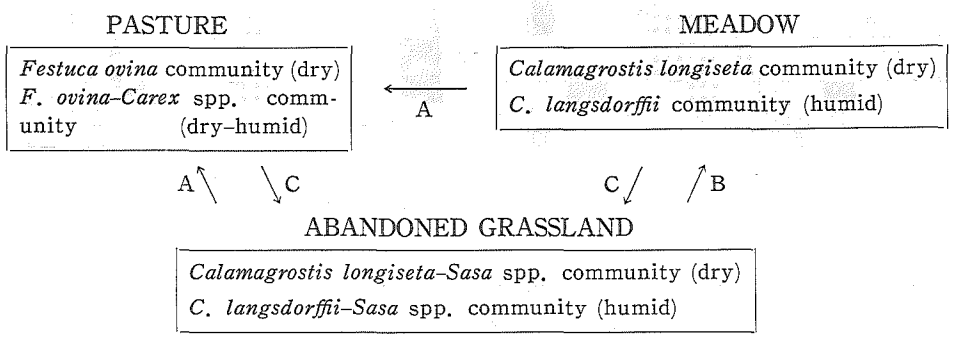

Fig. 12. Relationships among pasture, meadow and abandoned grassland.
A: grazing B: cutting C: abandonment

As mentioned above, Numata (1969a) proposed the grassland zones and types based on the dominant species in Japan under mowing or grazing (see Table 1 and Fig. 1). According to these, the preceding grassland types in the subalipine zone of Central Japan coincide with the grassland types in the subarctic region, Hokkido district. On the grassland vegetations in Hokkaido, there are some reports as follows: (1) the northern limit of distribution of *Zoysia* type pastures and *Miscanthus* type meadows are southwest regions of Hokkaido corresponding with the distribution of *Fagus crenta* forest which is the climax vegetation in the cool–temperate region (Numata 1961, 1969b, Suganuma 1966, 1974, Miyawaki & Ohba 1970, Yano et al. 1971, Tsuchida 1976a, (2) *Zoysia japonica* sociation, *Zoysia macrostachya* sociation, *Festca rubra* sociation and *Miscanthus sinensis* sociation as xeric and nutral pastures and meadows, and *Phleum pratense* sociation, *Carex* spp. sociation, *Calamagrostis langsdorffii* sociation and *Molinia japonica* sociation as moist pastures and meadows (Tatewaki 1942), (3) *Poa pratensis–Phleum pratense* community as cultivated grasslands (Miyawaki 1962), (4) *Poa* type or forage type as the preceding grasslands (Numata 1961, 1962a), (5) *Sasa* type grasslands as pastures and meadows (Tatewaki & Tsujii

1966, Oohara et al. 1968, Numata 1969a) and (6) *Festuca rubra* type as pastures (Nishimura & Adachi 1975). There are large areas of artificial or cultivated grasslands in Hokkaido (Numata 1961), where is very similar in climatic conditions to the dairy region in northern Europe and northern U. S. A., and is suitable for the growth of introduced northern type grasses such as Kentucky blue grass, orchard grass, timothy, white clover, red clover, red fescue, etc. (Kawanabe 1956). *Sasa* type pastures and meadows had extended widely in Hokkaido, but they have been improved to artificial grasslands. Most of *Sasa* spp. are associated with forest communities as their undergrowth in the cool-temperate, subalipine and subarctic zone. When the forests were felled or burnt, there remain a dense growth of *Sasa* spp. which cover almost completely the felled forest land. Most of the *Sasa* type grasslands result from such disturbance. The dominants of dwarfbamboo grasslands in Hokkaido are *Sasa senanensis*, *S. nipponica* and *S. kurilensis*.

There are phytosociological studies on the grassland vegetation based on the species composition throughout Japan (Suganuma 1966, 1967, 1974, Miyawaki 1977, Itow 1974). Thes are all the studies on the *Zoysia japonica* type as pastures and the *Miscanthus sinensis* type as meadows in warm- and cool-temperate zones of Japan, but there are few studies in subarctic and subalpine zones. According to phytosociological studies (Suganuma 1974), *Miscanthus sinensis* grasslands in Japan are integrated Miscanthetea sinensis (class) and Miscantetalia sinensise (order), and are classified tow alliances : Arundinello-Miscanthion sinensis in Kyushu to the southwest Hokkaido and Lygodio-Miscanthion sinensis in Ryukyu Islands. Most representative *Miscanthus sinensis* grasslands in Japan, Arundinello-Miscanthion has the character species such as *Arundinella hirta*, *Solidago virga-aurea* var. *asiatica*, *Haloragis micrantha*, *Gentiana scabra* var. *buergeri*, *Aster scaber*, *Pteridium aguirinum*, *Adenophora triphylla* var. *japonica*, *Lespedeza bicolor* f. *acutifolia* and *L. cyrtobotrya*. Arundinello-Miscanthion sinensis is classified seven associations. Convallario-Miscanthetum sinensis among these associations is considered the upper limit of altitudinal distribution of species of *Miscanthus sinensis* and *Miscanthus sinensis* grasslands, and has character species such as *Convallaria keiskei*, *Veratrum maackii* var. *japonicum*, *Viola patrini*, *Hemerocallis vespertina*, *Polygonum bistorta*, *Geranium soboliferum*, *Polygonatum humile*, *Smilax biflora* var. *trinervula* and *Sasa nana* (Miyawaki & Ohba 1970, Suganuma 1974). Numata (1966c) suggested that the high presence species of *Miscanthus sinensis* grasslands based on survaying all over Japan are *Miscanthus sinensis*, *Pteridium aquilinum*, *Lespedeza bicolar* f. *acutifolia*, *Arundinella hirta*, *Lysimachia clethroides*, *Artimisia princeps*, *Cirsium japonicum*, *Potentilla freyniana*, *Carex lanceolata* and so on. The *Zoysia japonica* grasslands in Japan consist of one order, Caricetalia nervatae, one alliance, Zoysion japonicae and four associations, and the order and the alliance occupy the area of Fagion Crenatae,

cool-temperate climax forest. Alliance Zoysion japonicae has the character species such as *Zoysia japonica* grasslands in Japan consist of one order, Caricetalia nervatae, one alliance, Zoysion japonicae and four associations, and the order and the alliance occupy the area of Fagion crenatae, cool-temperate climax forest. Alliance Zoysion japonicae has the character species such as *Zoysia japonica*, *Hydrocotyle ramiflora*, *Ranunculus japonicus*, *Luzula capitata*, *Carex albata* and *Viola obtusa*. The associations which develop in the most northern regions, and southwest Hokkaido are Violo-Zoysietum and Geranio-Zoysietum. The character species of Violo-Zoysietum are as same as those of the alliance and those of Geranio-Zoysietum are *Geranium nepalense* var. *thunbergii*, *Agrimonia pilosa* and *Moehringia lateriflora*. Only *Moehringia lateriflora* among these character species occurs in the *Festuca ovina* type pastures with low dominance. Among the character species of Miscanthetea sinensis, Miscanthelalia sinensis, Arundinello-Miscanthion sinensis and Convallario-Miscanthetum sinensis, *Potentilla freyniana*, *Arundinella hirta*, *Solidago virga-aurea* var. *asiatica*, *Adenophora triphylla* var. *japonica*, *Convallaria keiskei*, *Veratrum maackii* var. *japonicum* and *Polygonum bistorta* occur in the *Calamagrostis longiseta* type meadows. Among these species, *Arundinella hirta*, *Cirsium japonicum*, *Potentilla freyniana* are common to the *Miscanthus sinensis* grassland and the *Calamagrostis longiseta* grassland. Thus the floristic composition is considerably different between *Zoysia japonica* type pastures and *Festuca ovina* type pastures, while there are many common species between *Miscanthus sinensis* type meadows and *Calamagrositis longiseta* type meadows.

Apart from the subarctic region, Hokkaido, there are few reports on the pastures and meadows in other areas of Japan. As one example, Ishizuka (1975) reported the *Calamagrostis langsdorffii* grassland community which is cut for skiing every year in the snowy subalpine zone (1,600-1,650m in altitude) of Mt. Zao in Tohoku district. This community results from human disturbances in *Sasa kurilensis* community, which remained as the undergrowth when timbers of the *Abies mariesii* forest were logged down, and the prominent species are *Calamagrostis langsdorffii*, *Sasa kurilensis*, *Sanguisorba albiflora*, *Solidago virgaaurea* var. *asiatica*. This grassland type is similar to the *Calamagrostis langsdorffii* type meadows in Central Japan.

Natural herbaceous communities of the subalpine region in Japan were classified phyotsociologically into twenty associations (Ohba 1974, 1976). These communities occur in snow avalanche tracks, collapse lands or snowy places of the montane, subalpine, and alpine zone and are dominated by *Cirsium* spp., *Angelica* spp., *Saussurea* spp., *Aconitum* spp., etc.

Hartley (1954, 1966) showed that the specific diversification of some of the larger tribes of the Gramineae throught the world exhibits a regular pattern, and the distribution of major grass tribes (excluding the Aveneae) in any region

closely relates to the climatic factors. Especially, the distribution of the Agrosteae (including *Calamagrostis*, *Agrostis*, etc.) and the Festuceae (including *Festuca*, *Poa*, *etc.*) is determined strongly by temperature of climatic factors. According the Hartley's agrostological index, in which the percentage of grasses in each tribe is included in one of 10 frequency groups, the composition of high value for the percentage of Agrosteae and high value for the percentage of Festuceae in the floras occurs in the most northern regions of the Northern Hemisphere and in the most southern regions of the Southern Hemisphere within the grass distribution, which these areas are characterized by low temperatures. Kawanabe (1968) suggested that the temperature responses for growth and germination of the Gramineae vary in subfamily level such as Festucoideae, Eragrostoideae and Panicoideae, and that the subfamilies Festucoideae (including genera *Festuca*, *Calamagrostis*, *Agrostis* and so on) consisted of only species of the cool type, while the members of the subfamilies Eragrostoideae and Panicoideae are of the warm type. The predominant species of the grasslands in the subalpine region, Central Japan, *Festuca ovina*, *Calamagrostis longiseta* and *C. langsdorffii* belong to the tribe Festuceae and subfamily Festucoideae and distribute mainly in the region of cool-temperate from montane zone to alpine zone in Japan.

In the world wide scale, there are few reports on the grasslands dominated by preceding species. Numata (1965b, 1966b) suggested that the pasture vegetation in Estern Nepal was divided into two types, namely the Panicoideae–Eragrostideae grassland below 2,000m in altitude and the Festucoideae grassland in the cold temperature zone above 2,000m. The arid grazing grassland of the vicinity of Mongolia in the Chinese Continent was dominated by *Festuca ovina* and *Artemisia* spp. In England, the *Festuca ovina/rubra* type is the most widespread of all chalk grasslands and *Festuca ovina–Agrostis* spp. grassland, the most widespread of all acidic grasslands, occurs in Wales, the Pennins, the Southern Uplands and the Central Highlands (Cornish 1954, Duffey al. 1974). In south-east Scotland, the *Festuca ovina–Agrostis* spp. grassland was widespread, too (King 1962, Burnet 1964). As grassland climax of North America, the Fescue grasslands dominated by *Festuca scabrella* extend over western Canada, especially in the areas characterized by short, moderately warm summers, long, cold winters and a deficiency of moisture (Coupland & Brayshaw 1953, Looman 1969). There are some local descriptions of *Festuca* spp. grasslands and *Calamagrostis* spp. grasslands in the high altitudinal or subalpine meadows of U. S. A. (e. g. Kuramoto & Bliss 1970, Douglas & Bliss 1977).

As the Semi-natural grassland in the subalpine zone of Central Japan, the *Festuca ovina* type pastures (dry habitat), the *Calamagrostis longiseta* meadows (dry habitat), the *C. langsdorffii* meadows (humid habitat) and *C. longiseta–Sasa* spp. (dry habitat) or *C. longsdorffii–Sasa* spp. (humid habitat) abandoned grasslands were recognized.

2. Relationships among pastures, meadows and abandoned grasslands.

The pasture vegetation is generally the short-grass type due to continuous disturbances such as livestook's trampling and grazing, and the constituent species having strong ability for regeneration are prominent. While, the meadow vegetation is normally tall-grass type and is periodically mowed or cut, and tussock plants (t), rosette (r) and tempeorary rosette (ps and pr) in growth forms which hold out against mowing orcutting dominate. However, the dowarf-bamboo (*Sasa* spp.) and woody plants which have not so big resistance to mowing or cutting reduce (Shimizu et al. 1971). In abandoned grasslands which were released from abovementioned biotic factors, various seral communities occur and they are generally seral vegetations toward the *Sasa* community.

Now, according to the author's data, dominants of pastures are *Festuca ovina*, *Carex oxyandra*, *Agrostis clavata*, *Scabiosa japonica*, *Carex nanella*, *Juncus tenuis* and *Carex nervata*. Six species except *S. japonica* show short tussock forms (t). *Scabiosa japonica* which is a winter annual having partial rosette form (Numata 19 65a) hold out against trampling and is distasteful plant for livestock. Oseko (1937) suggested that *Scabiosa japonica* is an indicator of heavy grazing. *Juncus tenuis* is a characterspecies of trampling community in Japan (Miyawaki 1964). In meadows, the dominants more than 60% in SDR are *Calamagrostis longiseta*, *Cirsium iaponicum*, *Scabiosa japonica*, *Sasa nana* and *Calamagrostis langsdorffii*. Among these, *Calamagrostis* spp. are tall-grasses having the tussock form and may be seral equivalent (Numata 1961) with *Miscanthus sinensis* in the *Miscanthus* type grassland. *Scabiosa japonica* having a temporary rosette form can remain against cutting (Hogetsu et al. 1963). *Sasa* spp. which have very strong regenerative power of rhizome can considerably bear the light cutting, but cannot bear the heavy cutting or grazing (Oohara et al. 1968, Iwata & Matsumura 1975). Short-grasses and-herbs having tussock, rosette or temporary rosette form such as *Carex* spp., *Solidago virga-aurea* var. *asiatica*, etc. and creeping plants such as *Geranium yesoense* var. *nipponicum*, *Trifolium lupinaster*, *Potentilla freyniana*, etc. can relatively remain against cutting, too.

The abandoned grasslands are floristically richer. Their dominent species are *Calamagrostis longiseta*, *C. langsdorffii*, *Sasa senanensis*, *S. nana*, *Solidago virga-aurea* var. *asiatica*, *Geranium yesoense* var. *nipponicum*, *Hemerocallis dumortieri* var. *esculenta*, *Cirsium japonica*, *Adenophora triphylla* var. *japonica*, *Rhododendron japonicum*, etc. They considerably resemble the dominants of preceding meadows. While, *Calamagrostis* spp. and tall herbs such as *Cirsium* spp., *Adenophora triphylla* var. *japonica*, *Sanguisorba officinalis*, *Polygonum cuspidatum* and so on are prominent in the upper part of community, and *Solidago virga-aurea* var. *asiatica*, *Sasa* spp., *Geranium yesoense* var. *nipponicum*, *Hemerocallis dumortieri* var. *esculenta*

and so on dominate in the low layer of communities. Thus floristic richness is due to enlarging space utilization of plants (Numata 1965a). These grasslands have developed from pastures and meadows, and have progressed toward a *Sasa*–shrubs community (Tsuchida 1976a, 1979).

On the whole, dominants of pastures, *Festuca ovina* and *Agrostis clavata* occur with very low dominance in meadows and abandoned grasslands, and the species compositions of the latter two are considerably similar, but abandoned grasslands are characterized by florstic richness, *Sasa* spp. and tall–herbs with high dominance, and invation of shrubs.

Regarding the bilogical spectrum, the combination of dominant types is HD_1 or D_4R_3t in pastures, HD_4R_3e or t in meadows and HD_1 or D_4R_3e or t in abandoned grsslands. These express the grassland condition and trend (Numata 1965a). Nakano (1944) suggested that the dominant dormancy form of montane grasslands in Japan is Hemicryptophyte (H). According to (Numata 1965a), the dominant biological types based on both the number of species and on SDR are HD_1 or D_4R_5e or t in short–grass or *Zoysia* type grasslands used for grazing, HD_1 or D_4R_5e or t in high–grass or *Miscanthus* type grasslands used for mowing, and H or Ph D_1R_{1-3} or R_5e in *Sasa*–type grasslands used for grazing in Hokkaido. Suganuma (1967) suggested that the dominant biological type of semi–natural pastures is HD_1 or D_4R_5e or t according to both the number of species and the dominance–presence index. Compared with the author's surveyed grasslands in the subalpine zone, the dormancy, disseminule and growth forms are similar, but the radicoid form is different. It is considered that the lower rate of R_5 than of R_3 in the grasslands of the subalpine zone is owing to floristic poverty and low dominance of Ph (shrubs) or Th (annual plants) generally having R_5 form as mentioned above. The grassland type, species composition and community structure of grasslands in the subalpine zone, Central Japan were considerablly elucidated, but phytosociological studies have not still progressed.

VI. SUMMARY

1. The types and structures of grassland vegetation in the subalpine zone, Central Japan were studied.
2. Nineteen stands in eight areas were selected and investigated.
3. The representative grassland types were recoginzed as follows : *Festuca ovina* type (in dry place) and *Festuca ovina–Carex* spp. type (in dry–humid place) in pastures, *Calamagrostis longiseta* type (in dry & mesic place) and *C. langsdoffii* type (in humid place) in meadows, and *C. longiseta–Sasa* spp. type (in dry & mesic place) in abandoned grasslands.
4. The combination of dominant biological types is HD_1 or D_4R_3t in the *Festuca*

type grassland, HD_4R_3e or t in the *Calamagrostis* type grassland and HD_1 or D_4R_3e or t in the *Calamagrostis–Sasa* type grassland.

5. These grassland types develop in the subalpine zone of Central Japan and resemble relatively the native grassland types in Hokkaido, subarctic region of Japan.

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VIII. LITERATURE

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IX. APPENDIX

EXPLANATION OF PHOTOGAPHS

1. The *Festuca ovina* type pasture on the Hachibuse Heights, 1,900m alt.
2. The *Festuca ovina* type pasture on the Utsukushigahara Heights, 1,900m alt.
3. A view of the skiing field where is cut every year. Takamine Heights, 2,000m alt.
4. The *Calamagrostis langsdorffii* type meadow on the Takamine Heights, 2,000m alt.
5. The *Calamagrostis longiseta–Sasa nana* type grassland on the Yunomaru Heights, 1,950m alt.
6. The *Festuca–Carex* type pasture (heavy grazing) and the *Sasa* type community (light grazing) on the Fujimidai Heights, 1,700m alt.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6