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Ecosystems and Monitoring of Miyatoko, Akaiyachi and Kushiro Mires

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Errata

Page ii, line 8 (contents):
For "17. Selection of Effective Spectral Bands with" read "17. Selection of Effective Spectral Bands from".

Page 63, line 13:
For "8.0°C" read "ca. 4°C" and for "ca. 4°C" read "8.0°C".

Pages 73-74:
Although the numbering of the captions in Figs. 2 and 3 on pages 73 and 74 are correct, the figures themselves were inadvertently switched.

Contents

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Preface

Mires, also known as peatlands, had long been considered as worthless areas which could not be used for housing, agriculture or other productive purposes. Extensive drainage of groundwater, peat extraction and land reclamation have fragmented or completely destroyed many mires in the past. Consequently, extant mires have become threatened landscapes.

Mires are classified according to their hydrological conditions as either bogs, fed only by precipitation, or fens, fed by surface and/or ground waters from their watersheds as well as by precipitation. Many of the previous studies on the classification of Japanese mires have been conducted based on vegetation, largely ignoring hydrology. A re-inventory of mires is therefore necessary for the conservation of these threatened landscapes.

The ecosystem approach is now widely applied to studies of lakes and forests or forest watersheds. Such an approach, however, has not been common in mire research. When, in 1991, we started a 5-year research project on the characteristics of wetland ecosystems and their resilience in the face of environmental change, we set as our research goal understanding of the structure and function of mire ecosystems. We firmly believed then, and remain convinced, that integrated information on mire ecosystems is essential for their conservation.

The present report deals with 3 Japanese mires of different scales, ecosystem structures, landscapes, geographical locations and levels of human impacts, studied between 1991 and 1995. Miyatoko Mire, the smallest of the 3 and located in a pass between mountains, seemed to be the least disturbed by human activities. This mire is a complex of bog and fen ecosystems. Akaiyachi Mire is located near a lake. This mire is now surrounded by irrigation ditches and rice paddies created by conversion of peatlands. Despite conversion of some of its land to agricultural uses, Akaiyachi Mire maintains its largely bog ecosystem intact. Kushiro Mire, located in the lowlands of Hokkaido, is the largest mire in Japan. This mire is mostly fen, having a vast watershed area. The human impact on Kushiro Mire seems to be highest among the 3 mires we studied.

We tried to develop methods for monitoring mire plants at different structure levels with various equipment, ranging from a conventional camera with interval operation capabilities and an airborne compact spectrum imager to Landsat data, according to the extent of mires. As mires are physically and chemically nourished by water, hydrological factors were studied intensively in the present study.

Our research on mires is continuing. Yet the present report may give some perspective on Japanese mires and the state-of-the-art of the monitoring methods we have developed and used. We would welcome critical comments from readers, which would surely improve our research and contribute to better understanding of mire ecosystems.

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Acknowledgements

All the mires which we surveyed are legally protected. We express our gratitude to the following organizations for permission to conduct the research presented here: the Cultural Properties Protection Department of the Agency for Cultural Affairs, the Fukushima Prefectural Department of Education, the Aizuwakamatsu City Board of Education and the Wakamatsu Forestry Office for the study of Akaiyachi Mire, the Fukushima Prefectural Department of Environmental Conservation, the South Aizu District Office of Fukushima Prefecture, the Tourism Division of Nango Village and the Tajima Forest Office of Fukushima Prefecture for the study of Miyatoko Mire, the Kushiro-Shitsugen National Park Office, and the Nature Conservation Bureau of the Environment Agency for the study of Kushiro Mire.

We thank the National Space Development Agency of Japan for providing Landsat and multispectral scanner (MSS) data on Kushiro Mire. The research on Akaiyachi Mire was performed partly as a project conducted by the Research Group on the Natural Monument-Akaiyachi Mire and was supported by the Aizuwakamatsu City Board of Education under the auspices of the Agency for Cultural Affairs and the Fukushima Prefectural Department of Education. Thanks are also due to Prof. Toshimichi Kashimura, Faculty of Education, Fukushima University, Prof. Tatsuichi Tsujii, Faculty of Agriculture, Hokkaido University and Prof. Hiroaki Sumida, College of Agriculture and Veterinary Medicine, Nihon University, for their critical comments and discussion of the present study.

PART I.   MIYATOKO MIRE

1
Environment of Miyatoko Mire

Toshio Iwakuma

A number of small- to medium-sized mires of several hectares to several tens of hectares in extent are located at altitudes of 600—1100 m in the Minami Aizu district of Fukushima Prefecture, central Honshu, Japan. Specifically these are Miyatoko (area 6.5 ha, altitude 830 m), Komado (area 27.3 ha, altitude 1100 m), Takashimizu (area 3 ha, altitude 660 m) and Yanohara (area 20.6 ha, altitude 660 m) Mires.

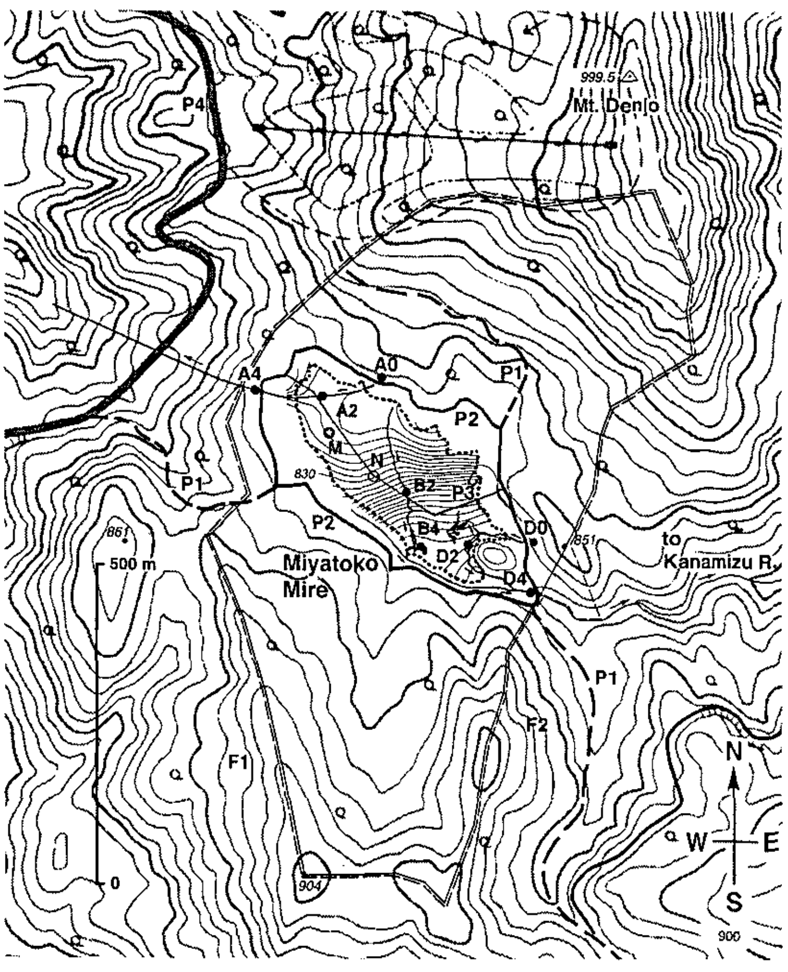

Fig. 1. Topographic map of Miyatoko Mire made by combining 1:25,000 scale maps (Aizuyamaguchi and Izumida, Geographical Survey Institute, 1990) with the results of a topographic survey in the mire. Contour lines in the mire are at 0.1 m intervals. M: meteorological monitoring tower; A0, A2, A4, B2, B4, C2, D0, D2, D4: sites of limnological and biological surveys. —: boundary of watershed; P1—P4: boardwalk, promenades or roads; •••: boundary of mire; - - -: boundary of Fukushima Prefectural Nature Conservation Area. (Redrawn from Iwakuma 1995).

Location and geological features of Miyatoko Mire

Miyatoko Mire (lat 37°14'48"N long 139°34'6"E, altitude 830 m) is located on a pass between Mount Denjo (altitude 999.5 m) and another mountain of 904 m altitude. Slopes of these mountains, which form the watershed of the mire, are covered with secondary deciduous forests dominated by *Quercus serrata* Thunb. ex Murray, *Q. crispula* Blume, *Magnolia obovata* Thumb. and *Alnus japonica* (Thumb.) Steud. (Takehara, 1995). The total area of the mire watershed is 54.1 ha.

The mire is elliptical in shape, measuring ca. 400 m along its longitudinal northwest to southeast axis and ca. 170 m across from northeast to southwest. The highest site is near the northeast tip of the short axis from where the ground slopes toward the southern tip of the mire. The height difference between the highest and lowest sites is 2.5 m (Nohara and Iwakuma, 1995a).

Several studies have been conducted in this mire since 1967 (Baba, 1969; Suzuki and Nishida, 1973). Flora and vegetation have been studied by Baba (1969), Kubota (1973), Higuchi (1975), Igarashi (1975) and Takehara (1995). No obvious change in vegetation has been detected during the past 30 years. Aerial photographs of these areas were taken in 1947 by the U.S. Army and after 1962 by either the Forestry Agency or the Geographical Survey Institute. Based on these photographs, forests within the watershed of the mire seemed to have remained unchanged during this period. The mire and its watershed areas have been designated by Fukushima Prefecture as a prefectural nature conservation area since 1975. A 40 cm wide boardwalk was built along the long axis of the mire in 1979 (Fig. 1).

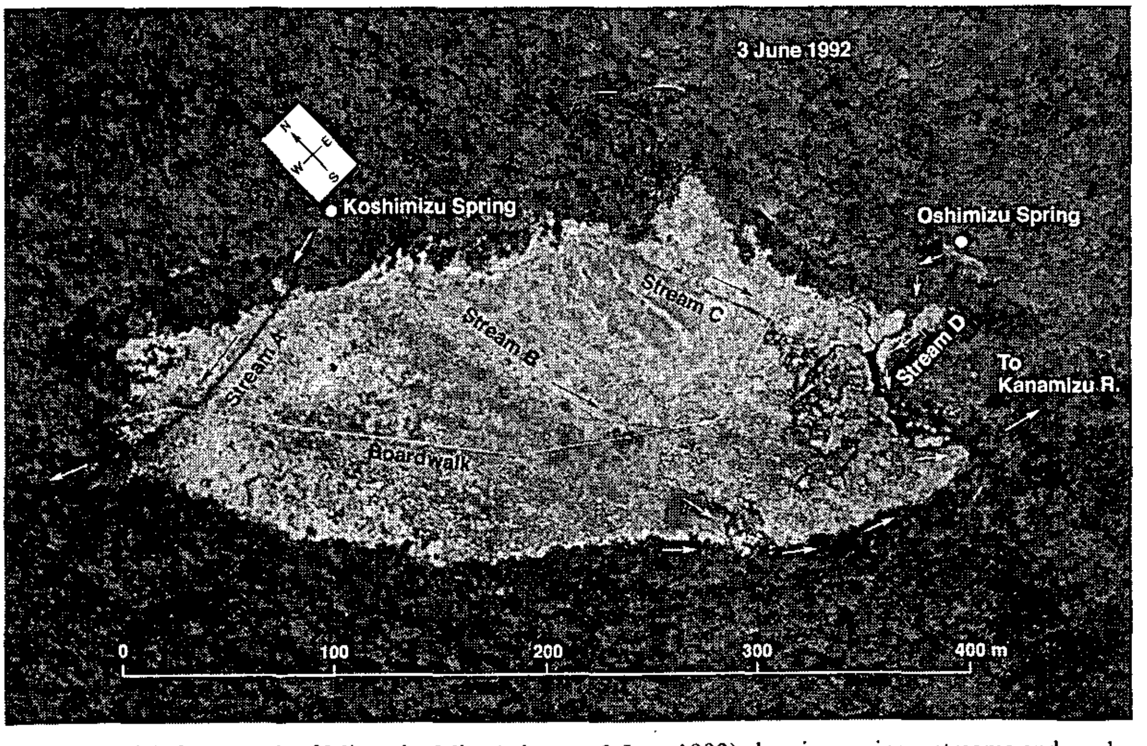

Fig. 2. Aerial photograph of Miyatoko Mire (taken on 3 June 1992) showing springs, streams and pools.

The bedrock of the mire is concave, like a lake basin (Suzuki and Nishida, 1973). The maximum peat depth is 6 m near the center of the mire based on cores taken at 20 locations (Suzuki and Nishida, 1973). The ^{14}C ages determined for the peat were 7000 BP for the 2.75—3.00 m depth interval (Choi and Hibino, 1985) and 11990 ± 250 BP for the 5.5—5.59 m depth interval (Kanouchi, 1991).

The mire is mostly covered with *Sphagnum fuscum* (Schimp.) Klinggr., *S. magellanicum* Brid, *S. palustre* L. and *S. papillosum* Lindb. and along the margin with a shrub, *Ilex crenata* Thumb. var. *paludosa* (Nakai) Hara (Takehara, 1995). There are four streams crossing the mire (streams A, B, C and D, Fig. 2). Streams A and D originate from springs at the foot of the slope of Mt. Denjo, flow into the mire and out of the northwest and southeast ends of the mire, respectively (sites A4 and D4, Fig. 1). Stream D flows through the lower southeast part of the mire. Stream B flows down the gentle slope in the mire, through a channel along the southwestern periphery of the mire, and finally out at site D4 (see Fig. 1). Site D4 is a headwater of the Kanamizu River, a tributary of the Tadami River.

Meteorology

A meteorological monitoring tower was set up near the northwest end of the mire in August 1991 (site M, Fig. 1). Air temperature, soil temperature at 10 cm depth, solar radiation, wind speed, and precipitation were recorded every 10 or 20 min (Nohara and Iwakuma, 1995b). Daily mean air temperature ranged from ca. -7°C to ca. 24°C and daily minimum and maximum air temperatures recorded during the period from August 1991 to November 1993 were -16°C and 30°C (Fig. 3a). Snowfall events were observed between November and April, and the mire surface was entirely covered with snow between December and March. Under the snow, soil temperature at 10 cm depth was a constant 0.4°C. Daily maximum soil temperature increased rapidly after snow thaw from 0.4°C to 7.3°C during the period from 16 to 18 April 1992 and from 0.4°C to 9.2°C during the period from 2-4 May 1993 (Fig. 3b). There was no indication of freezing in the peat soil. Solar radiation (Fig. 3c) was highest in May (20 MJ m^{-2} day^{-1} or 464 MJ m^{-2} $month^{-1}$). Daily mean wind speed fluctuated between 1 and 8 m s^{-1} throughout the year but the maximum wind speed often exceeded 20 m s-1 (Fig. 3e).

Annual mean (and minimum and maximum) air temperatures recorded at Nango Meteorological Observatory, 2.8 km northwest of the mire (lat 37°15'42"N long 139°32 '42"E, altitude 540 m until February 1991 and lat 37°15'48"N long 139°32'24"E, altitude 494 m after March 1991), were: 10.5 (-15.6—35.5) in 1990, 9.7 (-13.7—32.5) in 1991, 9.4 (-15.6—33.1) in 1992 and 9.1 (-10.8—30.9°C) in 1993 (Table 1). Annual duration of sunshine was 1342, 1239, 1389 and 928 h in 1990, 1991, 1992 and 1993, respectively. Annual precipitation was 1217, 1487, 1310 and 1440 mm in 1990, 1991,

The annual average air temperature for the year from July 1992 to June 1993 in the mire (7.9°C) was 1.5°C lower than that at the Nango Observatory (9.4°C). The precipitation for the June—November 1992 period in the mire (635 mm) was higher than that at the Nango Observatory (551 mm). The maximum snow depth recorded at

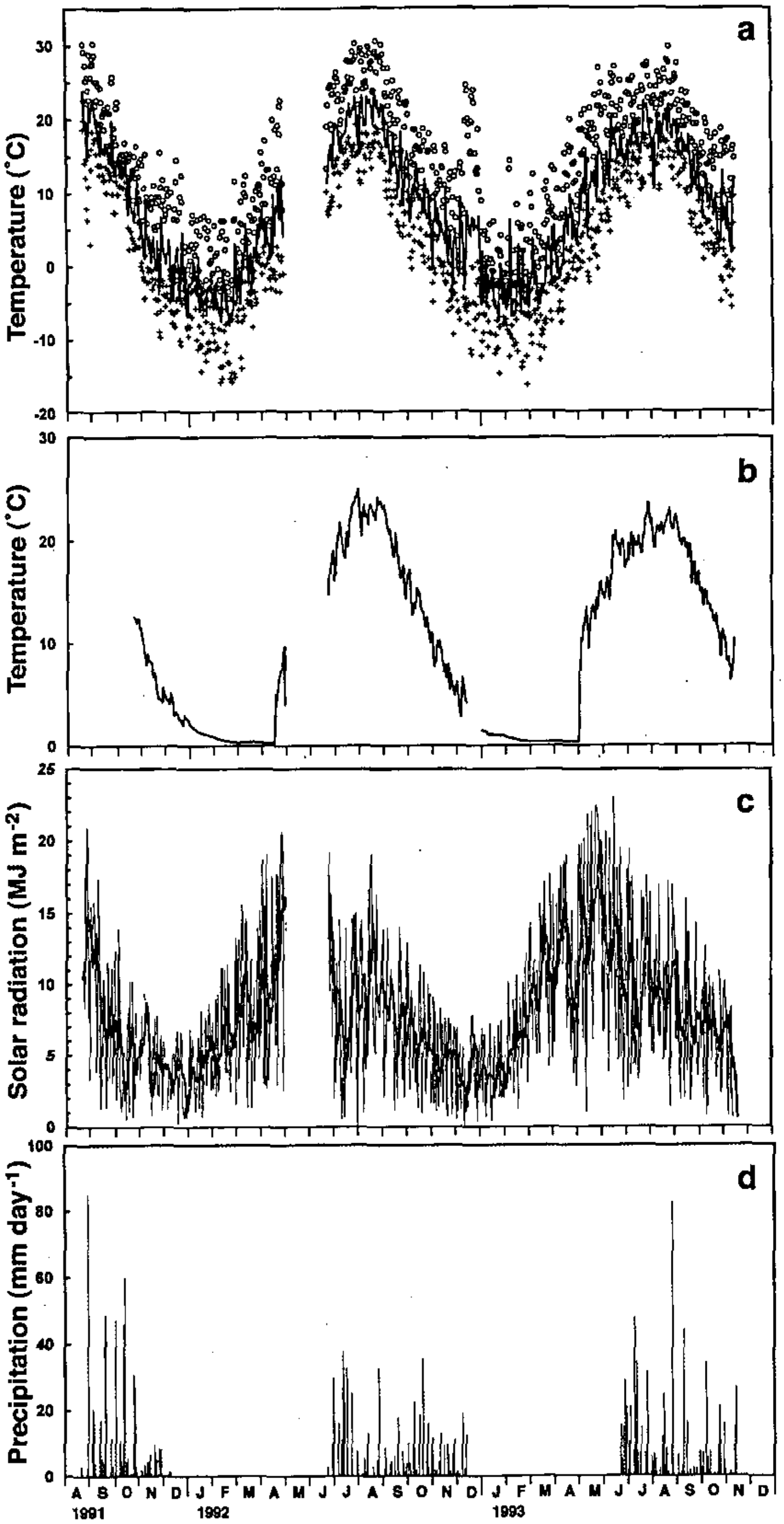

Fig. 3. Weather recorded at the monitoring tower in Miyatoko Mire. a: daily maximum (°), minimum (+) and mean (-) air temperatures; b: daily mean soil temperature; c: daily (—) and 7-day moving average (-) solar radiation; d: daily precipitation; e: daily maximum (—) and mean (-) wind velocity.

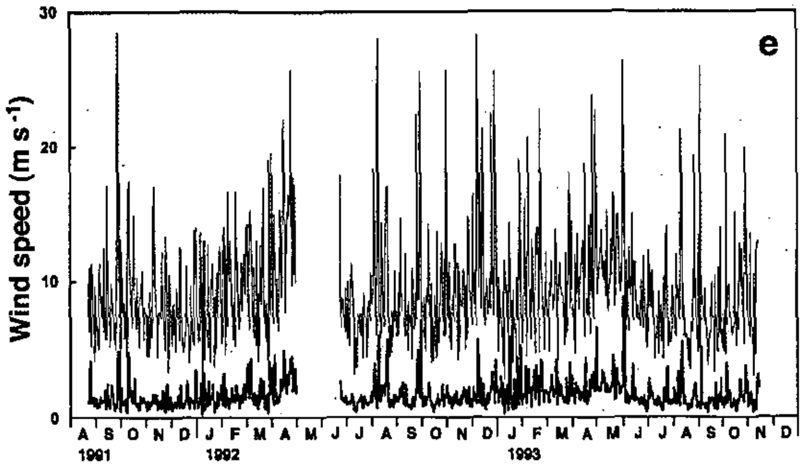

Fig. 3. continued.

Table 1. Comparison of monthly meteorological data at Miyatoko Mire with those at Nango Observatory (Iwakuma, 1995). * July 1992—June 1993; Ha.s.l. = above mean sea level.

Month	Miyatoko Mire (830 m Ha.s.l.)										Nango Observatory (494 m Ha.s.l.)						
	Air temperature			Wind speed		Solar radiation	Precipitation	Soil temperature			Air temperature			Wind speed		Sunshine duration	Precipitation
	Mean °C	Max. °C	Min. °C	Mean m s-1	Max. m s-1	MJ m-2	mm	Mean °C	Max. °C	Min. °C	Mean °C	Max. °C	Min. °C	Mean m s-1	Max. m s-1	h	mm
1991																	
Aug											21.7	32.1	9.1	2.0	6.0	137.1	205.0
Sep	17.6	30.3	7.4	1.5	28.5	262.2	155.0				19.4	31.0	10.5	1.8	12.0	98.9	146.0
Oct	10.7	22.4	2.4	1.5	17.5	120.2	289.0				12.7	22.9	4.7	1.8	7.0	67.7	256.0
Nov	2.7	15.6	-9.6	1.2	17.1	104.0	77.5	7.2	11.4	1.1	4.6	16.8	-4.6	2.1	8.0	97.0	71.0
Dec	-0.6	14.5	-10.7	1.4	14.1	92.6		3.4	5.6	1.1	1.3	13.4	-6.5	2.3	8.0	87.6	54.0
1992																	
Jan	-3.1	7.1	-14.3	1.4	13.7	142.3		1.3	2.1	0.8	-1.4	5.6	-10.4	2.2	10.0	90.3	87.0
Feb	-4.7	11.7	-15.8	1.7	16.7	180.8		0.5	0.9	0.3	-2.9	9.7	-15.6	2.6	9.0	93.6	89.0
Mar	0.5	12.4	-13.9	1.9	19.1	270.2		0.4	0.5	0.1	1.8	12.3	-8.2	2.6	10.0	106.8	72.0
Apr	6.0	22.5	-3.5	2.6	25.8	342.3		3.0	12.0	0.2	7.7	24.3	-2.2	3.3	11.0	155.4	107.0
May											11.7	23.7	-0.8	2.8	10.0	109.0	123.0
Jun											16.7	28.4	8.4	2.4	9.0	107.5	138.0
Jul	19.1	30.2	8.2	1.1	11.3	197.4	227.5	21.1	26.9	13.9	20.9	32.2	10.0	1.9	7.0	128.1	186.0
Aug	20.9	30.4	11.3	2.1	28.3	304.7	74.0	22.9	26.4	18.8	22.9	33.1	13.2	2.3	8.0	175.9	68.0
Sep	15.2	30.0	3.9	1.8	25.6	216.8	74.0	19.1	25.5	13.5	17.2	31.7	6.2	2.3	10.0	137.5	65.0
Oct	9.8	22.2	-0.4	1.4	25.7	199.5	171.0	13.6	19.1	8.4	11.7	24.6	0.8	1.9	8.0	110.8	165.0
Nov	4.1	16.2	-9.5	1.4	14.8	145.0	88.5	7.8	10.9	4.4	5.6	17.9	-5.3	2.2	8.0	116.7	67.0
Dec	3.9		-12.2	2.0	28.3	114.4		4.9	7.5	2.4	1.1	16.3	-12.4	2.3	10.0	57.1	143.0
1993																	
Jan	-3.2	8.8	-14.8	1.9	19.1	117.4		1.2	1.6	0.9	-1.5	8.0	-10.8	2.5	14.0	60.7	110.0
Feb	-3.2	14.2	-16.3	2.3	22.8	173.7		0.6	0.9	0.4	-1.4	8.4	-10.1	3.3	11.0	74.2	100.0
Mar	-1.3	13.4	-12.9	2.0	18.1	328.7		0.4	0.5	0.4	0.5	12.9	-8.2	2.9	10.0	137.9	33.0
Apr	3.4	19.8	-7.9	2.1	23.9	342.4		0.4	0.5	0.1	5.6	21.5	-3.6	3.0	12.0	129.7	56.0
May	10.3	26.8	-2.3	2.5	22.8	463.7		11.1	18.3	0.3	12.4	28.3	0.2	3.1	9.0	191.3	99.0
Jun	15.1	27.0	4.6	1.8	26.4	363.7		17.7	24.1	12.2	17.3	28.5	8.2	2.5	10.0	95.0	190.0
Jul	17.8	27.5	8.0	1.4	14.2	329.4	218.0	20.2	25.9	15.2	19.9	29.2	11.1	2.1	6.0	71.4	188.0
Aug	18.3	29.8	-3.0	1.7	21.4	297.4	213.5	21.0	25.1	18.5	20.7	30.9	12.8	2.0	8.0	91.5	200.0
Sep	15.5	27.5	4.3	1.3	26.0	235.8	118.0	19.1	24.3	13.8	17.4	28.8	6.5	1.8	8.0	82.0	80.0
Oct	8.5	19.9	-5.0	1.5	21.0	205.8	151.5	13.0	17.0	7.0	10.6	21.6	-2.2	2.0	9.0	112.1	164.0
Nov											6.4	22.7	-5.9	2.3	9.0	106.6	103.0
Dec											0.3	14.7	-8.2	2.7	10.0	75.6	117.0
Annual*	7.8	30.4	-16.3	1.9	28.3	2967		10.1	26.9	0.1	9.4	33.1	-12.4	2.5	14.0	1414	1282

Fig. 4. Location of pools in Miyatoko Mire based on an aerial photograph taken on 3 June 1992. Pool numbers in italics. B2, B4, C2, D1, D2, E1, E2: Observation sites.

1992 and 1993, respectively.
the mire by serial photography for the 1992 winter, 160 cm, was twice that recorded at the Nango Observatory.

Distribution of pools and streams

Stream A had been excavated during the Edo era for paddy irrigation. This stream starts from spring A0, crosses the northwestern part of the mire, where the peat surface elevation is higher than that in the southeastern part, and flows out from the northwestern tip of the mire.

About 50 pools are distributed in the southeastern part of the mire where the elevation is low (Fig. 4). Pools 1 to 3 are distributed along stream B and pool 50 is in the midst of stream D. Many smaller pools near Pool 50 are connected with it after rains. Most of the pools are distributed between streams B and D. This area is inundated after rains or snow thaw in late spring and the pools are connected with each other making stream D into a broad tributary stream (Fig. 5).

Snow melt water flows into the mire supplying nutrients to the soils and pools. The effects of nutrient supply from the watershed should be considered because the watershed area is much larger than the mire area. Miyatoko Mire is a complex of fen and bog ecosystems.

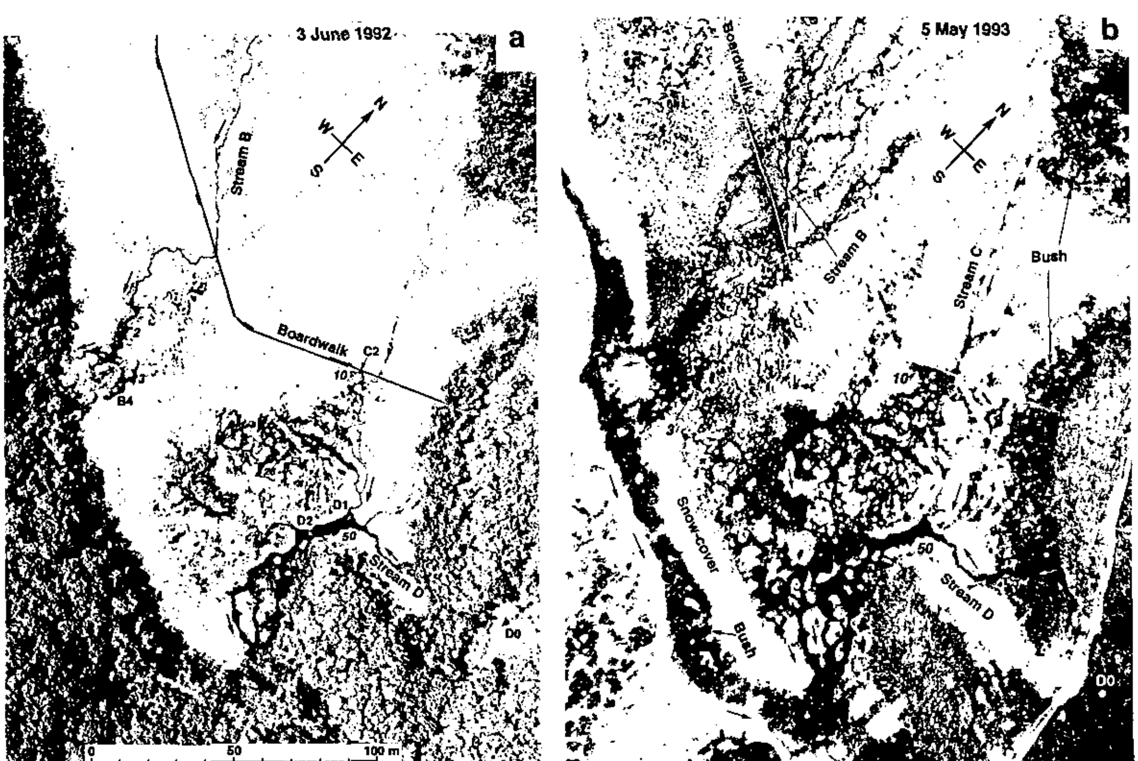

Fig. 5. Pool inundation in early summer and during snow melt in Miyatoko Mire. a: map drawn based on an aerial photograph taken on 3 June 1992; b: map drawn based on an aerial photograph taken on 5 May 1993.

In the present study of Miyatoko Mire, samples of water, algae and zoobenthos were collected along these streams or in the pools shown in Table 2. The results of studies of surface and groundwater chemistry, groundwater table variations and aquatic organisms are presented in Chapters 2, 3, 7, 8 and 9. Chapters 4, 5, 6 and 10 deal with the vegetation, pollinator insects and soil microbes.

Table 2. Physicochemical features and vegetation of the sampling sites in waters of Miyatoko Mire. Minimum and maximum values are shown for water temperature, pH and specific conductivity (Iwakuma, 1995).

Site		Depth (cm)	Width (m)	Current speed ($m\ s^{-1}$)	Vegetation	Sediment	Water temperature (°C)	pH	Specific conductivity ($\mu S\ cm^{-1}$)
A0	Koshimizu Spring	10	1.5	0.0	none	clay, litter	7.5—11.1	5.38—6.71	15.0—24.1
A2	Stream A, upstream of boardwalk	20	0.5	0.5	*Carex*	litter	5.5—14.8	5.49—7.05	12.8—25.7
A4	Stream A, outlet	20	1.5	0.5	*Potamogeton*	silt, litter	3.6—17.8	5.45—6.35	10.7—22.0
B2	Stream B, upstream of boardwalk	15	0.3	0.1	*Phragmites, Sphagnum*	litter	2.6—31.9	4.08—6.03	7.6—22.7
C2	Pool 10	20	3.0	0.0	*Nymphaea, Sphagnum*	litter	2.4—17.0	4.81—5.35	11.5—18.7
E1	Pool 26	20	3.0	0.0	*Nymphaea, Menyanthes*	litter	2.5—28.4	4.69—5.18	9.8—16.3
D0	Oshimizu Spring	20	2.0	0.0	none	clay, litter	8.0—10.8	5.39—6.63	16.6—29.3
D1	Pool 50	20	1.5	0.0	*Menyanthes*	litter	4.0—25.6	4.50—6.39	6.4—20.6
D2	Pool 50	30	5.0	0.0	*Menyanthes, Nymphaea*	litter	5.9—20.6	4.92—6.83	11.0—25.0
D4	Stream D, outlet	40	5.0	0.0	*Lysichiton*	clay, litter	1.1—21.4	5.25—6.28	7.9—18.6

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