FORTY-YEAR CHANGES IN HAGER LAKE FEN, BONNER COUNTY, IDAHO

by

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ABSTRACT

The peatland surrounding Hager Lake, Bonner County, Idaho, is of high biodiversity value in Idaho, containing populations of ten rare plant species. The vegetation was originally described by John Rumely in the early 1950's, while a graduate student at Washington State University. In 1992, with the help of Dr. Rumely, we reconstructed his study to document floristic, vegetational, and water chemistry changes that have occurred at Hager Lake Fen during the last 40 years.

Numerous plant species have increased or decreased in prominence in all portions of the fen, including on the fixed and floating mats surrounding the lake, in the littoral zone of the lake, and in the *Spiraea douglasii*/*Carex lasiocarpa* carr north of the lake. Fourteen species have disappeared completely from the fen, including four rare species, *Carex leptalea*, *Dryopteris cristata*, *Epilobium palustre*, and *Lycopodium obscurum*

Two factors appear to be responsible for these changes: altered hydrologic regimes and changes in the mineral content of surface waters. Ditching and draining of the lake and fen has affected the fixed mat and littoral vegetation by lowering the lake level and water table. This change favors the growth of mesophytic species over hydrophytic ones. Although the floating mat should be relatively unaffected by water level fluctuations, substantial compositional changes were also documented here. In this case, changes in the mineral content of surface and subsurface waters may account for these forty-year differences. Succession of adjacent forests after fire and logging may be responsible for some of these changes.

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INTRODUCTION

Valley peatland ecosystems in Idaho generally form around small lakes or ponds at relatively low elevations. They are inhabited by numerous boreal species of limited distribution in the region. Structural attributes of valley peatland ecosystems include floating and fixed mats on the margins of lakes that are dominated by Sphagnum spp., including S. angustifolium, S. centrale, and S. subsecundum, along with Carex spp., particularly C. lasiocarpa and C. limosa (Bursik 1990). Although valley peatlands occur throughout much of the northern Rocky Mountains of the U.S, in Idaho and adjacent states, they are widely scattered and rare on the landscape as a whole. Many species restricted to valley peatlands are rare in Idaho (Moseley and Groves 1992) and, consequently, valley peatland conservation is of paramount concern in the state.

Hager Lake Fen (HLF) is a valley peatland of high biodiversity value in Idaho, containing populations of ten rare plant species, eight of which are Forest Service Sensitive Species. It has been the site of several paleoecological (Hansen 1939; 1947; Rumely 1956; Mack et al. 1978) and vegetation ecology (Rumely 1956) studies, as well as more recent floristic (Bursik 1990) and limnological (Rabe et al. 1986) treatments. In an informal comparison of Rumely's (1956) results with those of the two recent studies, we noticed that obvious floristic, vegetational, and water chemistry changes had taken place in HLF in the last 40 years.

During the summer of 1992, we set out to ascertain the full extent of the changes by reconstructing Rumely's vegetational study of HLF. This was a cooperative project between the Idaho Department of Fish and Game's Conservation Data Center and the Idaho Panhandle National Forests. Dr. John Rumely, professor emeritus, Montana State University, assisted with the field work in 1992 to help replicate the original study as closely as possible. Our study appears to be the first to document recent peatland changes in the western U.S., although similar studies have been undertaken in the midwest (Schwintzer and Williams 1974).

We plan on using this shorter-term, 40-year view of peatland change in concert with long-term, 12,000-year vegetation trend data from ongoing paleoecology studies to develop models of composition and structure changes in peatlands under fluctuating climates and management. Models for community development and landscape evolution supported from these studies can provide enlightened and long-term management strategies, not only for valley peatlands in Idaho, but for Rocky Mountain ecosystems as a whole.

STUDY SITE DESCRIPTION

Hager Lake is a 2-ha pond located in the Priest River Valley, Bonner County, Idaho. It is approximately five km south of Nordman and six km west of Priest Lake, at an elevation of 860 m above sea level (Figure 1). The basin is enclosed and underlain by ice-contact fluvial gravels (Mack *et al*. 1978). The depression likely formed as a result of an ice block melting near the terminus of the glacier that occupied this portion of the Priest River Valley. Mack *et al*. (1978) estimated the depression dated from approximately 10,500 years before present. Cores taken from the peatland in 1992, however, indicate that it is somewhat older; the presence of Glacier Peak ash near the bottom of the cores place the origin from between 11,500 and 12,000 years before present (P. Mehringer, Washington State University, unpublished data).

The climate of the Priest River Valley has been described as "inland maritime" due to the prevailing westerlies, which carry maritime air masses from the northern Pacific Ocean across the northern Rocky Mountains during the winter and spring (Cooper *et al*. 1987). Mean annual precipitation for the Priest River Experimental Forest, the nearest weather station, 32 km southeast of Hager Lake, is 81.3 cm, most of which occurs during the winter (November through March). Snowfall accounts for more than 50 percent of the total precipitation. The mean annual temperature is 6.8^{o}C, while the mean July temperature is 18.2^{o}C and the mean January temperature is -4.6^{o}C.

Hager Lake is bordered on the south by a one-hectare floating sphagnum mat that is dominated by *Sphagnum angustifolium*, *S. subsecundum*, *Scheuchzeria palustris*, *Vaccinium oxycoccos*, and *Kalmia microphylla*. A narrow, 10-meter wide fixed mat, dominated by *Carex lasiocarpa* and *Dulichium arundinaceum*, borders the lake to the east, north, and west. A similar fixed mat community occurs between the floating mat and a dense thicket of *Spiraea douglasii* south of the lake. The *Spiraea* thicket surrounds the fixed-mat zone around the entire lake, extending from the fixed mat to the peat-mineral soil boundary on the east, west, and south sides of the lake (see Figure 2).

Approximately 15 m to the north of Hager Lake is a narrow stand of *Pinus contorta* that occupies a moraine that is raised more than one meter above the level of the lake. Beyond the moraine, to the north, is an extensive *Spiraea* thicket that grades into a *Spiraea*/*Carex lasiocarpa* carr that covers 25 hectares (Figure 2).

Figure 1. Location of Hager Lake Fen in the Priest River Valley, Bonner County, Idaho [modified from Mack et al (1978)].

Figure 2. Map of plant communities at Hager Lake Fen [modified from Rumely (1956)].

The forests surrounding Hager Lake are comprised of mixed coniferous species of varying ages, including Pinus contorta, P. monticola, P. ponderosa, Abies grandis, Pseudotsuga menziesii, Picea engelmannii, Thuja plicata, and Tsuga heterophylla.

Humans have had impacts on the ecology of HLF for most of the 20th century. The Homestead Patent, including the lake and surrounding fen communities was granted in 1915. The forests to the west and east of the basin were logged in 1926 and again in 1945. The forest to the south of the lake was severely burned and subsequently cleared of slash in 1930 (Rumely 1956). Individuals of Pinus monticola were harvested from stands adjacent to the west side of HLF in 1955.

Hager Lake Fen has been affected by a series of ditching episodes that date back to the early part of this century (Rumely 1956). The most recent ditching took place during the summer of 1988. Although Hager Lake lies in a depression with no natural surface outlet, ditching has affected the water level of the lake and the water table of the carr to the north. A drainage ditch exits the lake from the northeast corner and runs along the eastern edge of the carr to the north where it is joined by three east- to west-running ditches traversing the carr (Figure 2). After the first ditching and draining episode, the Spiraea/Carex lasiocarpa carr was cleared of shrubs and hay was cut from this area up to the early 1940's. Phleum pratense, Agrostis stolonifera, and Dactylis glomerata were sown in the native sedges to improve hay quality. During the early 1940's, the former carr was also used as a goat pasture. Rumely (1956) reported that the area had not been pastured or cut since 1947. From Rumely's vegetational data, it appears that the native vegetation and presumably the hydrology had recovered by the early 1950's, as the introduced grasses failed to show up in the plot data, although they did appear in his checklist of the flora.

METHODS

Water Chemistry and Lake Depth

Subsurface water samples from the floating mat and Spiraea/Carex lasiocarpa carr habitats, as well as surface samples from the lake were taken for water chemistry analysis in 1952 (Rumely 1956), 1987 and 1988 (Rabe unpublished data, open water only), and again in September 1992.

Our analysis of the water samples differed from those of Rumely (1956) who employed: the Nesslerization method for nitrogen; the vanadate method for phosphorus; thiozole-yellow method for magnesium; and flame spectrometry for calcium and potassium.

We (and Rabe, unpublished data) measured conductivity on site with an YSI Model 33 S-C-T conductivity meter. For macronutrients, alkalinity, and pH, samples were collected and kept on ice for analysis at the Water Resources Laboratory at the University of Idaho. Macronutrient concentrations including calcium, magnesium, sodium, and potassium were measured by Inductively Coupled Plasma Atomic Emissions Spectroscopy. Alkalinity was measured by titration of 100 ml of water sample with 0.02 N sulfuric acid after adding methyl orange indicator solution. Nitrates were measured by colorometric extraction and orthophosphates by cadmium reduction. Measurements of pH were made with a Fischer Acumet model 815MP pH meter.

In 1987, Rabe (unpublished data) established three permanently-marked macroinvertebrate sampling stations at Hager Lake. He used these stations to measure lake depth in 1987 and 1988, prior to the most recent episode of ditching. We measured depths at two of these stations in September 1992.

Flora

During the course of his field work at Hager Lake in the early 1950's, Rumely (1956) compiled a detailed checklist of the peatland vascular flora, as well as those species occurring in the surrounding forests. Beginning in 1987 (Bursik 1990), and continuing through 1992, we again compiled a checklist of the peatland flora. Upland species from Rumely's list where omitted in order to make direct temporal comparisons of the peatland flora.

We collected voucher specimens of all vascular and bryophyte species encountered. Voucher specimens of vascular species are deposited at the University of Idaho Herbarium (ID) and Marion Ownbey Herbarium (WS) at Washington State University. Bryophyte vouchers have been deposited at ID and the Oregon State University Herbarium (OSC). Vascular plant nomenclature follows Hitchcock and Cronquist (1973), while bryophyte nomenclature follows Crum *et al*. (1973). Rumely's voucher specimens are also housed at WS and, where possible, we verified their identification and updated the nomenclature to conform with Hitchcock and Cronquist (1973).

Vegetation

We used Rumely's (1956) methods to replicate the original study as closely as possible. A transect was placed length-wise through the center of HLF at 324^{o} (roughly northwest) from the south end of the lake (Figure 2). The transect begins at the peat/mineral soil interface. From south to north, it traverses the *Spiraea* thicket, fixed mat, floating mat, open-water, littoral zone on the north side of the lake, fixed mat, raised moraine, *Spiraea* thicket, and *Spiraea*/*Carex lasiocarpa* carr. This transect is very close to Rumely's original transect. For instance, like Rumely, we encountered 100 m of transect from the peat/mineral soil interface to the edge of the lake.

The transect reference point at the north edge of the lake used by Rumely was difficult to locate because of vegetation and water level changes. Our final decision for reference point "G" (the lake margin in 1952; Figure 2) is probably within five meters of that used by Rumely, using the moraine as a reference point. Therefore, we feel all direct comparisons of vegetation zones from the littoral zone to "G" and beyond are valid.

Plot lines were placed every five meters along the transect on the south side of the lake and in the littoral zone, fixed mat, and 15 m from the 1952 lake margin ("G") into the *Spiraea* thicket north of "G". Beyond 15 m, the vegetation is relatively homogeneous in broad zones and the sampling interval was increased to 30 m. Plot lines ran perpendicular to the transect within what appeared to be a homogeneous vegetation zone. Each line consisted of ten 20 cm x 50 cm plots placed at one meter intervals. The line deviated from the perpendicular to maintain vegetational homogeneity only at two places; the boundary between the floating and fixed mats south of the lake (40 m) and the lake margin/floating mat margin (100 m).

Frequency and mean percent cover were computed for each species on each plot line using the midpoints of five cover classes: 1 = 1-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-100% (Braun-Blanquet 1932). Mean percent cover values were rounded to the nearest whole numbers. These values were used to compute prominence values (PV) for each species on each plot line using the formula PV = C F, where C = mean percent canopy cover and F = absolute frequency (Beals 1960). The coverage of *Sphagnum* species were estimated separately, but these values were lumped into "*Sphagnum* spp." for consistency with Rumely's methodology.

Our transect was permanently marked with steel fence posts for the future monitoring of HLF. One post was placed five meters south of the peat/soil interface at the southern point of the transect. Another post was placed five meters north of "G" on the raised moraine.

RESULTS

Water Chemistry and Lake Depth Changes

Water chemistry data for floating mat, open water, and *Spiraea*/*Carex lasiocarpa* carr habitats from 1952 and 1992 are summarized in Table 1. Major differences are noted for nitrates, potassium, calcium, and magnesium concentrations. With the exception of potassium and orthophosphates, all were higher

Table 1. Comparison of nutrient concentration, alkalinity, conductance, pH, and temperature in floating mat, open-water, and *Spiraea*/*Carex lasiocarpa* carr habitats of Hager Lake Fen from 1952, 1988 (open-water only), and 1992. Nitrates, orthophosphates, calcium, magnesium, and total alkalinity are in mg/liter. Conductivity is measured in micromhos/cm^3.

	Habitat						
	Floating Mat		Open-water			Carr	
Year	1952	1992	1952	1988	1992	1952	1992
nitrates	3.60	0.10	3.60	-	0.10	3.60	0.30
orthophosphates	0.00	0.06	0.00	-	0.00	0.00	0.12
potassium	0.00	2.10	0.00	0.90	0.00	0.00	1.00
calcium	14.00	1.00	11.60	2.00	2.00	9.60	7.00
magnesium	2.44	0.00	2.44	0.50	0.00	7.38	0.00
sodium	-	1.80	-	2.00	0.60	-	4.70
total alkalinity	-	7.00	-	5.00	6.00	-	11.00
conductivity	-	35.0	-	15.0	25.0	-	72.0
pH	-	5.7	-	6.5	7.2	-	5.6
temperature	-	16.0	-	-	13.0	-	13.0

in 1952 than in 1992. Potassium was apparently below detectable levels in all habitats in 1952, but was clearly detectable in 1992 in the floating mat (2.10 mg/l) and in the carr (1.00 mg/l). Phosphate concentrations were below detectable limits in all habitats in 1952 and at very low levels in 1992 (0.06 mg/l on the floating mat, 0.00 in surface water, and 0.12 in the carr). The concentration of nitrates, calcium, and magnesium were higher in all habitats in 1952 than in 1992 (Table 1).

Differences in the mineral composition of water between the peatland habitats in 1992 are also clear (Table 1). The concentration of some minerals (nitrates, ortho-phosphates, potassium, iron, sodium) were lowest in the open-water and highest in the carr. Calcium ion concentration was highest in the carr and lowest on the floating mat. Alkalinity and conductivity were lowest in the open-water and highest in the carr. The pH of the floating mat and the carr ground waters were similar (5.7 and 5.6, respectively) and significantly higher in the open water (7.2).

Table 2 shows seasonal variation in pH, conductivity, alkalinity, temperature, transparency, and depth. Seasonal variation for pH, conductivity, and alkalinity are slight. Water depth fluctuated 30 to 40 cm during 1987 and 1988, respectively. Water levels were lower at both stations in September 1992, particularly at station #2, which has apparently seen the affects of increased littoral sedimentation, causing the water level to drop considerably farther than at station #3.

Table 2. Physical and chemical data for surface water of Hager Lake in 1987, 1988, and 1992.

	1987			1988			1992
	May	June	July	May	June	July	Sept.
pH	5.9	6.3	6.1	5.9	6.5	6.2	7.2
conductivity (micromhos/cm^3)	12.0	13.0	17.0	15.0	15.0	16.0	25.0
total alkalinity (mg/l)	-	-	-	6.0	5.0	4.0	6.0
temperature (C^o)	16.0	23.0	27.0	20.0	25.0	21.0	13.0
transparency (cm)	75.0	115.0	105.0	79.0	103.0	67.0	76.0
sampling station #2 depth (cm)	96.0	110.0	80.0	104.0	103.0	67.0	15.0
sampling station #3 depth (cm)	95.0	109.0	79.0	103.0	103.0	64.0	51.5

FLORISTIC CHANGES

Table 3 lists species occurring in the HLF in 1952 (Rumely 1956) and in 1992. Fewer species were present in 1992 (n = 74) than in 1952 (n = 76). We found seven bryophyte species during 1992, while Rumely noted only four, though it is likely the other species were also present. We, like Rumely, found both *Pinus contorta* and *P. monticola* individuals in HLF. Rumely found 70 species of ferns and flowering plants, while we found 65 species. Our collections include nine species not listed by Rumely. Five of the nine are weedy species of peatland margins and disturbed ground within peatlands (e.g., *Cerastium vulgatum* and *Phalaris arundinacea*), however, four species typically occur in undisturbed wetland habitats (*Agrostis scabra*, *Eleocharis pauciflora*, *Panicum occidentale*, and *Utricularia minor*). The latter four species are diminutive or blend in with dominant species and can be easily overlooked, although it is distinctly possible that they first arrived at HLF during the last forty years.

Fourteen species have disappeared from HLF since 1952. Only two of these species, *Rumex acetosella* and *R. occidentalis*, are weedy opportunists. Of the remaining 12 species, four have disappeared from aquatic habitats of Hager Lake, including *Alisma plantago-aquatica*, *Potamogeton amplifolius*, *Ranunculus aquatilis*, and *Utricularia vulgaris*. Eight species of rich fen and carr habitats are now absent, including *Carex aperta*, *Deschampsia cespitosa*, *Pedicularis groenlandica*, and *Cystopteris fragilis*, as well as the state-rare species *Carex leptalea*, *Dryopteris cristata*, *Epilobium palustre*, and *Lycopodium obscurum* (Moseley and Groves 1992).

VEGETATION CHANGES

Vegetational changes have occurred in most of the peatland zones described by Rumely (1956). Prominence values of species along the vegetational transect are displayed in Tables 4 through 10. The tables are divided into vegetation zones around Hager Lake.

Spiraea douglasii Thicket

Table 4 displays prominence values for species in the *Spiraea douglasii* thicket bordering the floating and fixed mats at the south end of HLF. Rumely (1956) noted this zone to be 15 to 25 m wide, while we found it to have expanded by approximately five meters at the transect and likely elsewhere around the lake. *Spiraea* increased considerably in prominence from 20 to 30 m, while the prominence of *Carex lasiocarpa*, *Dulichium arundinaceum*,

Table 3. Checklist of vascular and bryophyte species occurring in Hager Lake Fen in 1952 (Rumely 1956) and in 1992. Taxa are given in alphabetical order, presence in the flora in 1952 and 1992 are noted with an "X". (* indicates Idaho and U.S. Forest Service sensitive species [Moseley and Groves 1992])

Taxon	1952	1992
BRYOPHYTA		
Calliergon stramineum (Brid.) Kindb.	-	X
Pellia epiphylla (Gott.) Limpr.	X	X
Polytrichum juniperinum Hedw.	X	X
Sphagnum angustifolium C. Jens.	X	X
Sphagnum centrale C. Jens.	-	X
Sphagnum subsecundum Nees	X	X
Sphagnum teres (Schimp.) Angst.	-	X
CONIFEROPHYTA		
Pinus contorta Dougl.	X	X
Pinus monticola Dougl.	X	X
ANTHOPHYTA		
Agrostis scabra Willd.	-	X
Agrostis alba L.	X	X
Alnus incana (L.) Moench	X	X
Alisma plantago-aquatica L.	X	-
Amelanchier alnifolia Nutt.	X	X
Anaphalis margaritacea (L.) B. & H.	X	X
Brasenia schreberi Gmel.	X	X
Calamagrostis canadensis (Michx.) Beauv.	X	X
Carex aperta Boott	X	-
Carex arcta Boott	X	X
Carex canescens L.	X	X
Carex interior Bailey	X	X
Carex lasiocarpa Ehrh.	X	X
Carex leptalea Wahl.*	X	-
Carex limosa L.	X	X
Carex rostrata Stokes	X	X
Carex vesicaria L.	X	X
Cerastium vulgatum L.	-	X
Cirsium arvense (L.) Scop.	X	X
Cirsium vulgare (Savi) Airy-Shaw	X	X
Cornus stolonifera Michx.	X	X
Crataegus douglasii Lindl.	X	X
Cystopteris fragilis (L.) Bernh.	X	-
Deschampsia cespitosa (L.) Beauv.	X	-
Drosera anglica Huds.	X	X
Drosera rotundifolia L.	X	X
Dryopteris cristata (L.) Gray*	X	-
Dulichium arundinaceum (L.) Britt.	X	X
Eleocharis palustris (L.) R. & S.	X	X
Eleocharis pauciflora (Lightf.) Link	-	X
Epilobium angustifolium L.	X	X

Table 3 continued.

Taxon	1952	1992
Epilobium glandulosum Lehm.	X	X
Epilobium palustre L.*	X	-
Equisetum fluviatile L.	X	X
Equisetum pratense Ehrb.	X	X
Eriophorum chamissonis C.A. Mey.	X	X
Eriophorum gracile Koch	X	X
Galium trifidum L.	X	X
Geum macrophyllum Willd.	X	X
Glyceria borealis (Nash) Batch.	X	X
Hieracium albiflorum Hook.	X	X
Hypericum majus (Gray) Britt.*	X	X
Hypericum perforatum L.	X	X
Juncus ensifolius Wikst.	X	X
Kalmia microphylla (Hook.) Heller	X	X
Lycopodium inundatum L.*	X	X
Lycopodium obscurum L.*	X	-
Lycopus uniflorus Michx.	X	X
Lysimachia thyrsiflora L.	X	X
Menyanthes trifoliata L.	X	X
Nuphar polysepalum Engelm.	X	X
Panicum occidentale Scribn.	-	X
Pedicularis groenlandica Retz.	X	-
Phalaris arundinacea L.	-	X
Phleum pratense L.	X	X
Poa pratensis L.	X	X
Potamogeton amplifolius Tuckerman	X	-
Potamogeton natans L.	X	X
Potentilla norvegica L.	-	X
Potentilla palustris (L.) Scop.	X	X
Ranunculus aquatilis L.	X	-
Rumex acetosella L.	X	-
Rumex occidentalis Wats.	X	-
Salix geyeriana Anderss.	X	X
Solidago canadensis L.	X	X
Scheuchzeria palustris L.*	X	X
Scirpus acutus Muhl.	X	X
Scirpus subterminalis Torr.*	X	X
Spiraea douglasii Hook.	X	X
Spiranthes romanzoffiana Cham.	X	X
Trifolium repens L.	X	X
Trientalis arctica Fisch.*	X	X
Utricularia minor L.	-	X
Utricularia vulgaris L.	X	-
Vaccinium oxycoccos L.*	X	X
Verbascum thaspus L.	-	X
Veronica scutellata L.	-	X
Viola macloskeyi Lloyd	X	X
Viola palustris L.	X	X

table 4

and *Potentilla palustris* decreased substantially in the same area. *Sphagnum subsecundum* also increased in prominence at 15 to 25 m in this zone, where it occurs in the understory of the *Spiraea* thicket.

Fixed Mat

The *Spiraea* thicket grades gradually into a narrow 5 to 10 m wide fixed-mat zone dominated by *C. lasiocarpa*, *D. arundinaceum*, *Lycopus uniflorus*, *Sphagnum subsecundum*, *Drosera anglica*, and *Lycopodium inundatum*. In 1992, this zone occurred between 30 and 40 m on the transect, while in 1952, it occurred between 20 and 40 m (Table 5). The shrinking of this zone is due to the expansion of *Spiraea* from the south (20 to 30 m) and from expansion of *Kalmia microphylla* and *Vaccinium oxycoccos* from the lakeward side (40 m). There has been an overall increase in the prominence of *Sphagnum subsecundum* and *Lycopodium inundatum* in this zone during the last 40 years while *C. lasiocarpa* has decreased in prominence.

Fixed Mat-Floating Mat Transition

A narrow band of slightly raised habitat marks the boundary between the fixed and the floating mats. Rumely (1956) did not discuss this zone, although it is apparent from his data at 45 to 55 m in 1952, and from our data at 40 to 50 m (Table 6). The transition from the fixed mat zone to this raised zone is indicated by the increase in prominence of *Sphagnum* spp. (at 45 m in 1952 and at 40 m in 1992). *Sphagnum angustifolium*, *S. subsecundum*, and *Calliergon stramineum* are the dominant bryophytes in this zone. *Kalmia microphylla* and *Vaccinium oxycoccos* are the dominant vascular species.

Changes have occurred in this zone. *Carex rostrata*, prominent in this zone in 1952, was absent in 1992 (Table 6). Conversely, *Eleocharis pauciflora*, not documented by Rumely (1956) in HLF, was common in 1992 from 40 to 50 m. Several species, including *Carex limosa*, *Drosera anglica*, *Menyanthes trifoliata*, and *Scheuchzeria palustris*, maintained similar levels of prominence in this zone.

The floating mat extends from approximately 55 to 100 m. There are three vegetational zones on the floating mat, all somewhat obscured by broad ecotones.

Floating Mat: Sphagnum Lawn

The first vegetation zone on the floating mat extends from 55 to 70 m (Table 7). It is characterized by a *Sphagnum subsecundum/S. angustifolium* lawn, with little microtopographic relief. There is a complete cover of *S. angustifolium* on slightly raised areas and of *S. subsecundum* in slightly depressed areas. *C. lasiocarpa* table 5

table 6

table 7

and Kalmia microphylla were not found in this zone (60 to 75 m) in 1952, although they were common in 1992. Drosera anglica decreased between 1952 and 1992, while D. rotundifolia increased in prominence. Carex limosa reached its highest prominence in this floating mat zone, although it has decreased since 1952.

Floating Mat: High-hummock Zone

The middle floating mat zone is the least stable of the three. It consists of high Sphagnum angustifolium and S. centrale hummocks with shallow pools of water between. This zone extended from approximately 75 to 90 m in 1992 and from 75 to 95 m in 1952 (Table 8). In general, the high-hummock zone was more distinct in 1952 than in 1992. Carex rostrata decreased substantially in this zone between 1952 and 1992 (mean PV=476 in 1952 versus mean PV=35 in 1992). Several species, including Carex canescens, C. limosa, Scheuchzeria palustris, and Vaccinium oxycoccos were absent in 1952, but were common in 1992.

Floating Mat: Low-hummock Lake Margin

A relatively stable, low-hummock lake margin zone extended from approximately 95 to 100 m in 1992 and was evident only at 100 m in 1952 (Table 8). Carex lasiocarpa was prominent in 1992, though less so than in 1952. Carex rostrata and C. canescens did not occur in this zone. Several species appear in this zone that do not occur in the high-hummock zone. These include Carex interior, Drosera anglica, Dulichium arundinaceum, and Lycopus uniflorus. Vaccinium oxycoccos increased considerably from 1952 to 1992, much as it did in the high hummock zone (Table 8). Carex limosa first appeared in this zone in 1992, and Scheuchzeria palustris increased in prominence at the mat margin in the forty-year interval, while Menyanthes trifoliata, Kalmia microphylla, Drosera rotundifolia, and Viola macloskeyi maintained similar PVs.

Littoral and Lake Margin Zones

The littoral vegetation zones on the north side of the lake also changed considerably (Table 9). The margin of the lake (Rumely's reference point"G") was at least 10 m farther north in 1952 than it was in 1992.

The deep littoral zone 15 m south of "G" in 1992, corresponds with the zone 20 m south of "G" in 1952 (Table 9). The PV of Nuphar polysepalum was higher in 1992 (PV=620 at 15 m) than in 1952 (PV=285 at 20 m), however, Brasenia schreberi and Potamogeton natans, both prominent components in the deep littoral zone in 1952, were absent in 1992 (Table 9). Indeed, P.

table 8

table 9

natans is nearly extirpated from Hager Lake (only two non-flowering individuals were found in the entire lake in 1992) and B. schreberi has decreased substantially in prominence during the last 40 years (only scattered individuals were found in the shallow littoral zones in 1992). Rumely (1956) also noted the presence of two species in the deep littoral zone in 1952 that did not appear in his plots; Potamogeton amplifolius and Utricularia vulgaris, both of which are now extirpated from Hager Lake.

The middle littoral zone 10 m south of "G" in 1992, has no apparent analog in 1952. It is characterized by occasional clumps of N. polysepalum (PV=148) with few, scattered stems of Scirpus acutus (PV=40), Dulichium arundinaceum, and Eleocharis palustris in water 20 cm deep in July, 1992. This zone appears to be transitional between the N. polysepalum deep littoral zone and the S. acutus/D. arundinaceum shallow littoral zone described by Rumely (1956). The rare species, Scirpus subterminalis, noted by Rumely in this zone, was also present in 1992. Brasenia schreberi was present in this zone in 1992, though it did not appear in the plots.

Rumely (1956) described the shallow littoral zone at five m south of "G" and at "G" as a C. lasiocarpa-dominated zone with D. arundinaceum (PV=460 at five m south of "G") being the only other species reaching any degree of prominence. The prevailing vegetation in this non-inundated zone in 1992, hints at highly fluctuating water levels in Hager Lake in the recent past. Hydrophytic species (D. arundinaceum, N. polysepalum, and Scirpus acutus) occur in this zone along with more mesophytic species (S. douglasii and Lycopus uniflorus).

Spiraea douglasii Thicket

The dense stand of S. douglasii that surrounds the entire lake and fen communities was reencountered five meters north of "G" in 1992 (Table 10). Rumely also encountered this thicket at five meters north of "G". The Spiraea thicket is characterized by high prominence values for Spiraea (mean PV=862 in 1992) and low prominence values for the few species in the understory of the thicket. Polytrichum juniperinum and Pinus contorta were the only other species of prominence in 1992. In 1952 the thicket was approximately 10 m broad, covering only the raised moraine. We found the thicket to extend nearly 100 m north into the carr in 1992. Additionally, Pinus contorta had high prominence values throughout this zone in 1992, while Rumely noted the presence of only few individuals on the moraine.

table 10

table 10 cont.

Spiraea douglasii/Carex lasiocarpa Carr

The S. douglasii/C. lasiocarpa carr occupied the central portion of HLF north of the lake in 1952 and in 1992 (Figure 2). The size and structure of this carr community changed between 1952 and 1992. It stretched from 15 to 285 m north of "G" in 1952 and from only 105 to 225 m north of "G" in 1992 (Table 10). In both years it was dominated by C. lasiocarpa and Spiraea. However, C. lasiocarpa decreased considerably in prominence between 1952 (mean PV=766) and 1992 (mean PV=218) while Spiraea increased (mean PV=158 in 1952; mean PV=419 in 1992).

Spiraea douglasii thicket

We reencountered the Spiraea thicket at 255 m north of "G" in 1992. Rumely (1956) reencountered the thicket at 315 m. In 1952, the remainder of the fen, from 315 to 405 m north of "G" was occupied by a dense stand of Spiraea with occasional clumps of Salix geyeriana (Table 10). In 1992 clear evidence of the Spiraea thicket ended at 315 m where the effects of ditching and clearing were apparent (e.g., Phleum pratense, PV=360 at 315 m, Table 10). The presence of Phleum pratense and Potentilla norvegica at 255 and 285 m are evidence that the carr was disturbed to approximately 240 m north of "G" where the first of three east- to west-running drainage ditches were encountered.

Ditched and Cleared Fen (1992)

In 1992, vegetation at the north end of the fen, which had been ditched and cleared in 1988 (315 to 465 m north of "G"), was characterized by a mosaic of patches of Spiraea, Phleum pratense, and Carex arcta (Table 10). The transect was longer in 1992 (reaching 465 m north of "G") than in 1952 (reaching 405 m north of "G") because our transect ran closer to due north than did Rumely's (1956). Consequently, our transect ran into the northeastern lobe of HLF (see Figure 2). The extreme northern portion of the fen was very wet in July 1992, (with shallow, standing water) and it was dominated by a hummocky stand of C. arcta (345 to 465 m north of "G"; Table 10). A number of weedy species were found scattered in the plots on the north end of the fen, including Potentilla norvegica, Agrostis alba, and others (Table 10). Analysis of slash piles near the ditches dug in 1988 indicated that lodgepole pine had also become well-established on the north end of the fen prior to ditching, much as it had increased in the Spiraea thicket just north of the lake.

DISCUSSION

Water chemistry values indicate that peatland habitats associated with Hager Lake are classified as poor fens. Calcium ion concentration on the floating mat (1.0 mg/l) is low enough to be considered within the range for true bogs, but true bogs typically have water pH less than 4.2 (Glaser 1987). The other water chemistries of all three habitats are generally within the poor fen range, consequently we have named the peatlands of the basin Hager Lake Fen to appropriately characterize its plant communities.

Significant vegetational changes occurred in HLF between 1952 and 1992. Several environmental factors could have influenced the documented changes, however, the two most important parameters affecting peatland vegetation are water level and surface and subsurface water chemistry.

Fluctuations of lake and groundwater water levels created by ditching episodes have dramatically altered the vegetation of HLF. Schwintzer and Williams (1974) found significant vegetational changes in a peatland in Michigan between 1917 and 1972, which they inferred to be caused by water table fluctuations. They found that the degree of change was greater in the fixed part of the fen versus the floating mat because the fixed mat, unlike the floating mat, did not rise or fall with water table fluctuations. In Hager Lake, however, we documented vegetation changes on the floating mat, as well as the fixed mat, littoral, and carr habitats.

Our data indicates that the mineral content of surface and subsurface waters of HLF generally decreased between 1952 and 1992. Water chemistry of surface and substrate waters are known to affect the relative abundance and distribution of plant species in peatlands (Jeglum 1971; Vitt and Slack 1975; Schwintzer 1978; Slack *et al*. 1980; Wheeler *et al*. 1983). Numerous environmental variables, including groundwater movement, fire, logging in adjacent areas, and acid precipitation, could directly or indirectly affect water chemistry in peatlands.

Vegetation changes on the floating mat are attributable to these water chemistry changes. *Carex rostrata* is a species of minerotrophic fens in the northern Rocky Mountains and in other parts of its range (Wheeler *et al*. 1983; Hansen *et al*. 1988) and *Vaccinium oxycoccos* is a species of poor fen and bog conditions in northern Michigan, at least (Slack *et al*. 1980). The decrease in prominence of *C. rostrata* and the increase in *V. oxycoccos* throughout the floating mat between 1952 and 1992 may indicate a transition from rich fen to poor fen conditions on the floating mat. This is supported by evidence of decreases in nitrates, calcium, and magnesium concentrations in surface and subsurface waters of HLF during this period (Table 1).

Aquatic habitats have also changed at Hager Lake. *Potamogeton amplifolius* disappeared from Hager Lake between 1952 and 1992 and *P. natans*, which was prominent in the outer littoral zone in 1952, had nearly disappeared by 1992. Lakes that become more acidic and nutrient-poor have been found to undergo changes in aquatic macrophyte species composition (Roelofs 1983; Roelofs *et al*. 1984; Roberts *et al*. 1985; Yan *et al*. 1985). In lakes of the Adirondack Mountains, New York, this compostional change involves the disappearance of such acid-intolerant, eutrophic indicators, such as *Potamogeton amplifolius* and *P. natans*, which are replaced by soft water-tolerant species (Jackson and Charles 1988).

We can only speculate about factors causing the decrease in nutrient concentrations in waters of HLF. The area to the south of Hager Lake was burned and cleared in 1930 (Rumely 1956). Portions of the forest to the east and west of the lake were logged in 1926, 1945, and 1955. As forest regeneration occurred in these stands, it is likely that fewer minerals were leached into HLF. As a result, groundwater seeping into HLF became more oligotrophic. Species adapted to minerotrophic conditions would compete poorly for resources under these conditions while other species more tolerant of poor-fen conditions would expand into available habitat. This perhaps explains some of the vegetation changes in HLF.

Drainage ditches in fens lower the water table in adjacent areas, allowing shrubs to colonize habitat previously dominated by more hydrophytic graminoids and forbs (Glaser *et al*. 1981). The effects of ditching and prevailing drought conditions during the last several years were observed in HLF. The retreat of the lake margin between 1952 and 1992 and the relative dryness and stability of peat in the carr north of the lake, which allowed us to drive a four-wheel drive vehicle out for peat coring, are two examples providing evidence of lower than normal water levels.

The shrinking of the *Spiraea*/*Carex lasiocarpa* carr north of the lake was due to the expansion of the *Spiraea* thicket. It is apparent from Rumely's (1956) vegetation map that the *Spiraea* thicket has spread on all sides of the carr. Although the area from 15 to 285 m north of "G" had apparently been cut for hay and grazed until the mid-1940's, it appears that the native vegetation had reestablished itself in the fen by 1952. We assume this because *Spiraea* had established itself throughout the fen, but had not achieved high coverage. It does not appear that the *Carex lasiocarpa*/*Spiraea* fen (now the *Spiraea*/*Carex lasiocarpa* carr) encountered at 15 m north of "G" by Rumely was an artifact of human activities as he suggested. Otherwise, presumably the entire undisturbed portion of the carr would have been occupied by the *Spiraea* thicket in 1992. Clearly it was not.

The expansion of the Spiraea thicket into the Spiraea/Carex lasiocarpa carr to the north of the lake, is likely the result of lower water levels. During July 1992, water was observed flowing out of the drainage ditch on the northeastern side of Hager Lake. Indeed, water was flowing from the lake with the water level remaining well below the high water mark of 1952 (reference point "G"). Clearly, if the drainage ditch had been in place for a decade or more, the vegetation zone at "G" could not include both hydrophytic species such as N. polysepalum and Scirpus acutus along with mesophytic species such as Spiraea as it did in 1992 (Table 9).

Analysis of aerial photos from 1983 show that the old drainage ditch, running from the lake north into the carr, had been obscured from years of siltation and plant growth. The redredging of this ditch in 1988 has profoundly influenced the vegetation throughout the basin once again. The lake is now subject to wide fluctuations in water level, which will continue to affect the vegetation in the surrounding fen. The first step in any restoration of the peatland habitats at HLF must include the filling of drainage ditches in the fen, especially the ditch that exits the lake.

LITERATURE CITED

Beals, E. 1960. Forest bird communities of the Apostle Islands. Wilson Bulletin 72:156-181.

Braun-Blanquet, J. 1932. Plant sociology, the study of plant communities. McGraw-Hill, New York, NY. 439 p.

Bursik, R.J. 1990. Floristic and phytogeographic analysis of northwestern Rocky Mountain peatlands, U.S.A. Unpublished M.S. Thesis, University of Idaho, Moscow, ID. 37 p.

Cooper, S.V., K.E. Neiman, R. Steele, and D.W. Roberts. 1987. Forest habitat types of northern Idaho: a second approximation. General Technical Report INT-236. Ogden UT: U.S.D.A. Forest Service, Intermountain Research Station. 135 p.

Crum, H.A., W.C. Steere, and L. Anderson. 1973. A new list of mosses for North America north of Mexico. Bryologist 76:85-130.

Glaser, P.H. 1987. The ecology of patterned boreal peatlands of northern Minnesota: a community profile. Report 85 (7.14). U.S. Fish and Wildlife Service. 98 p.

Glaser, P.H., G.A. Wheeler, E. Gorham, and H.E. Wright, Jr. 1981. The patterned mires of the Red Lake peatland, northern Minnesota: vegetation, water chemistry, and landforms. Journal of Ecology 69:575-599.

Hansen, H.P. 1939. Pollen analysis of a bog in northern Idaho. American Journal of Botany 26:225-228.

Hansen, H.P. 1947. Postglacial forest succession, climate and chronology in the Pacific Northwest. American Philosophical Society Transactions 37:1-130.

Hansen, P.L., S.W. Chadde, and R.D. Pfister. 1988. Riparian dominance types in Montana. Miscellaneous Publication No. 49, Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula, MT. 411 p.

Hitchcock, C.L., and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA. 730 p.

Jackson, S.T., and D.F. Charles. 1988. Aquatic macrophytes in Adirondack (New York) lakes: patterns of species composition in relation to environment. Canadian Journal of Botany 66:1449-1460.

Jeglum, J.K. 1971. Plant indicators of pH and water levels in peatlands at Candle Lake, Saskatchewan. Canadian Journal of Botany 49:1661-1676.

Mack, R.N., N.W. Rutter, V.M. Bryant, Jr., and S. Valastro. 1978. Reexamination of postglacial vegetation history in northern Idaho: Hager Pond, Bonner Co. Quaternary Research 10:241-255.

Mehringer, P.; unpublished data, Department of Anthropology, Washington State University, Pullman, WA.

Moseley, R.K. and C.R. Groves. 1992. Rare, threatened and endangered plants and animals of Idaho. Second Edition. Idaho Department of Fish and Game, Conservation Data Center, Boise, ID. 38 p.

Rabe, F.W., R. Biggam, R. Breckenridge, and R. Naskali. 1986. A limnological description of selected peatland lakes in Idaho. Journal of the Idaho Academy of Science 22:63-90.

Rabe, F.W.; unpublished data, University of Idaho, Moscow, ID.

Roberts, D.A., R. Singer, and C.W. Boylen. 1985. The submersed macrophyte communities of Adirondack lakes (New York, U.S.A.) of varying degrees of acidity. Aquatic Botany 21:219-235.

Roelofs, J.G.M. 1983. Impact of acidification and eutrophication on macrophyte communities in soft waters in the Netherlands. I. Field observations. Aquatic Botany 17:139-155.

Roelofs, J.G.M., J.A.A.R. Schuurkes, and A.J.M. Smits. 1984. Impact of acidification and eutrophication on macrophyte communities in soft waters. II. Experimental studies. Aquatic Botany 18:389-411.

Rumely, J.H. 1956. Plant ecology of a bog in northern Idaho. Ph.D. Dissertation, Washington State University, Pullman. 84 p.

Schwintzer, C.R. 1978. Vegetation and nutrient status of northern Michigan fens. Canadian Journal of Botany 56:3044-3051.

Schwintzer, C.R. and G. Williams. 1974. Vegetation changes in a small Michigan bog from 1917 to 1972. American Midland Naturalist 92:447-459.

Slack, N.G., D.H. Vitt, and D. Horton. 1980. Vegetation gradients of minerotrophically rich fens in western Alberta. Canadian Journal of Botany 58:330-350.

Vitt, D.H., and N.G. Slack. 1975. An analysis of the vegetation of *Sphagnum*-dominated kettle-hole bogs in relation to environmental gradients. Canadian Journal of Botany 53:332-359.

Wheeler, G.A., P. Glaser, E. Gorham, C. Wetmore, F. Bowers, and J. Janssens. 1983. Contributions to the flora of the Red Lake Peatland, northern Minnesota, with special attention to *Carex*. American Midland Naturalist 110:62-92.

Yan, N.D., G.E. Miller, I. Wile, and G.G. Hitchin. 1985. Richness of aquatic macrophyte floras of soft water lakes of differing pH and trace metal content in Ontario, Canada. Aquatic Botany 23:27-40.

Table 4. Prominence values for species from five to 30 m north of mineral soil along the transect through Hager Lake Fen in the Spiraea thicket.

Distance North of Mineral Soil	5 m		10 m		15 m		20 m		25 m		30 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Spiraea douglasii	850	850	880	850	850	880	640	880	580	850	13	390
Lycopus uniflorus	6	-	-	-	6	13	42	23	32	67	13	310
Carex interior	-	13	-	3	-	6	-	4	-	-	-	-
Carex arcta	-	36	-	-	-	-	-	-	-	-	-	-
Crataegus douglasii	-	3	-	3	-	-	-	3	-	-	-	-
Calamagrostis canadensis	-	3	-	-	-	-	-	-	-	-	-	-
Sphagnum spp.*	-	-	19	-	-	134	-	233	19	360	159	197
Alnus incana	-	-	13	-	-	-	-	-	-	-	-	-
Polytrichum juniperinum	-	-	-	3	-	-	-	6	-	-	-	-
Carex lasiocarpa	-	-	-	-	-	7	143	3	210	6	220	180
Potentilla palustris	-	-	-	-	-	6	13	6	190	3	32	-
Lysimachia thyrsiflora	-	-	-	-	-	6	-	6	-	6	-	4
Agrostis scabra	-	-	-	-	-	3	-	5	-	5	-	23
Viola palustris	-	-	-	-	6	-	-	-	-	-	-	-
Epilobium angustifolium	-	-	-	-	-	6	-	-	-	-	-	-
Dulichium arundinaceum	-	-	-	-	-	-	6	-	-	-	550	90
Juncus ensifolius	-	-	-	-	-	-	13	-	-	-	-	-
Menyanthes trifoliata	-	-	-	-	-	-	-	-	-	85	13	4
Kalmia microphylla	-	-	-	-	-	-	-	-	-	89	-	-
Amelanchier alnifolia	-	-	-	-	-	-	-	-	-	4	-	-
Lycopodium annotinum	-	-	-	-	-	-	-	-	-	3	-	-
Drosera anglica	-	-	-	-	-	-	-	-	-	-	67	47
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	-	-	3
Scheuchzeria palustris	-	-	-	-	-	-	-	-	-	-	-	4
Viola macloskeyi	-	-	-	-	-	-	-	-	-	-	-	30
Hypericum majus	-	-	-	-	-	-	-	-	-	-	-	18
Lycopodium inundatum	-	-	-	-	-	-	-	-	-	-	-	219
Vaccinium oxycoccos	-	-	-	-	-	-	-	-	-	-	-	-
Carex rostrata	-	-	-	-	-	-	-	-	-	-	-	-
Eleocharis pauciflora	-	-	-	-	-	-	-	-	-	-	-	-
Carex limosa	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum chamissonis	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium palustre	-	-	-	-	-	-	-	-	-	-	-	-
Spiranthes romanzoffiana	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum gracile	-	-	-	-	-	-	-	-	-	-	-	-
Carex canescens	-	-	-	-	-	-	-	-	-	-	-	-
Cystopteris fragilis	-	-	-	-	-	-	-	-	-	-	-	-
Pellia epiphylla	-	-	-	-	-	-	-	-	-	-	-	-
Calliergon stramineum	?	13	?	5	?	5	?	66	?	180	?	7

* = Sphagnum subsecundum
? = not included in Rumely (1956)

Table 5. Prominence values for species from 20 to 45 m north of mineral soil along the transect through Hager Lake Fen in the fixed-mat zone.

Distance North of Mineral Soil	20 m		25 m		30 m		35 m		40 m		45 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Spiraea douglasii	640	880	580	850	13	390	-	-	-	-	-	-
Lycopus uniflorus	42	23	32	67	13	310	-	250	-	85	-	3
Carex interior	-	4	-	-	-	-	-	3	-	-	-	-
Carex arcta	-	-	-	-	-	-	-	-	-	-	-	-
Crataegus douglasii	-	3	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-	-	-
Sphagnum spp.*	-	233	19	360	159	197	340	293	110	880	880	600
Alnus incana	-	-	-	-	-	-	-	-	-	-	-	-
Polytrichum juniperinum	-	6	-	-	-	-	-	-	-	-	-	-
Carex lasiocarpa	143	3	210	6	220	180	490	180	450	140	-	25
Potentilla palustris	13	6	190	3	32	-	117	4	180	18	6	6
Lysimachia thyrsiflora	-	6	-	6	-	4	-	4	-	5	6	-
Agrostis scabra	-	5	-	5	-	23	-	4	-	-	-	-
Viola palustris	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium angustifolium	-	-	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	6	-	-	-	550	90	-	240	3	35	-	-
Juncus ensifolius	13	-	-	-	-	-	-	-	-	-	-	-
Menyanthes trifoliata	-	-	-	85	13	4	92	-	133	100	170	80
Kalmia microphylla	-	-	-	89	-	-	6	-	-	240	160	270
Amelanchier alnifolia	-	-	-	4	-	-	-	-	-	-	-	-
Lycopodium annotinum	-	-	-	3	-	-	-	-	-	-	-	-
Drosera anglica	-	-	-	-	67	47	42	60	104	4	130	-
Drosera rotundifolia	-	-	-	-	-	3	-	4	-	60	16	100
Scheuchzeria palustris	-	-	-	-	-	4	100	27	150	100	130	110
Viola macloskeyi	-	-	-	-	-	30	-	18	-	3	-	-
Hypericum majus	-	-	-	-	-	18	-	-	-	-	-	-
Lycopodium inundatum	-	-	-	-	-	219	-	610	-	-	-	3
Vaccinium oxycoccos	-	-	-	-	-	-	13	-	104	250	290	410
Carex rostrata	-	-	-	-	-	-	95	-	80	-	210	-
Eleocharis pauciflora	-	-	-	-	-	-	-	4	-	4	-	78
Carex limosa	-	-	-	-	-	-	3	-	25	90	25	95
Eriophorum chamissonis	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium palustre	-	-	-	-	-	-	-	-	-	-	-	-
Spiranthes romanzoffiana	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum gracile	-	-	-	-	-	-	-	-	-	-	-	-
Carex canescens	-	-	-	-	-	-	-	-	-	-	-	-
Cystopteris fragilis	-	-	-	-	-	-	-	-	-	-	-	-
Pellia epiphylla	-	-	-	-	-	-	-	-	-	-	-	-
Calliergon stramineum	?	66	?	180	?	7	?	21	?	30	?	220

* = Sphagnum subsecundum
? = not included by Rumely (1956)

Table 6. Prominence values for species from 40 to 60 m north of mineral soil along the transect through Hager Lake Fen in the raised zone between the fixed and floating mats.

Distance North of Mineral Soil			40 m				45 m				50 m				55 m				60 m	
Year	'52	'92			'52	'92			'52	'92			'52	'92			'52	'92		
Spiraea douglasii	-	-			-	-			-	-			-	-			-	-		
Lycopus uniflorus	-	85			-	3			-	-			6	-			-	-		
Carex interior	-	-			-	-			-	-			-	-			-	-		
Carex arcta	-	-			-	-			-	-			-	-			-	-		
Crataegus douglasii			-	-			-	-			-	-			-	-			-	-
Calamagrostis canadensis	-	-			-	-			-	-			-	-			-	-		
Sphagnum spp.*	110	880			880	600			880	880			880	880			880	880		
Alnus incana	-	-			-	-			-	-			-	-			-	-		
Polytrichum juniperinum	-	-			-	-			-	-			-	-			-	-		
Carex lasiocarpa	450	140			-	25			-	-			-	-			-	7		
Potentilla palustris			180	18			6	6			-	-			-	-			-	-
Lysimachia thyrsiflora	-	5			6	-			-	-			-	3			-	-		
Agrostis scabra	-	-			-	-			-	-			-	-			-	-		
Viola palustris	-	-			-	-			-	-			-	-			-	-		
Epilobium angustifolium	-	-			-	-			-	-			-	-			-	-		
Dulichium arundinaceum	3	35			-	-			-	-			-	-			-	-		
Juncus ensifolius			-	-			-	-			-	-			-	-			-	-
Menyanthes trifoliata			133	100			170	80			150	110			59	45			-	15
Kalmia microphylla			-	240			160	270			114	110			150	60			-	27
Amelanchier alnifolia			-	-			-	-			-	-			-	-			-	-
Lycopodium annotinum			-	-			-	-			-	-			-	-			-	-
Drosera anglica	104	4			130	-			220	170			240	116			160	17		
Drosera rotundifolia			-	60			16	100			-	18			-	160			3	80
Scheuchzeria palustris			150	100			130	110			150	110			130	240			22	150
Viola macloskeyi	-	3			-	-			-	-			6	-			-	-		
Hypericum majus	-	-			-	-			-	-			-	-			-	-		
Lycopodium inundatum			-	-			-	3			-	-			-	-			-	-
Vaccinium oxycoccos	104	250			290	410			180	110			130	160			130	180		
Carex rostrata	80	-			210	-			75	-			98	-			-	-		
Eleocharis pauciflora			-	4			-	78			-	31			-	-			-	-
Carex limosa	25	90			25	95			89	210			240	170			310	170		
Eriophorum chamissonis	-	-			-	-			6	-			-	-			-	-		
Epilobium palustre			-	-			-	-			3	-			-	-			-	-
Spiranthes romanzoffiana	-	-			-	-			-	-			3	-			-	-		
Eriophorum gracile			-	-			-	-			-	-			-	-			57	-
Carex canescens	-	-			-	-			-	-			-	-			-	-		
Cystopteris fragilis			-	-			-	-			-	-			-	-			-	-
Pellia epiphylla	-	-			-	-			-	-			-	-			-	-		
Calliergon stramineum			?	30			?	220			?	30			?	30			?	19

* = Sphagnum angustifolium and S. subsecundum
? = not included by Rumely (1956)

Table 7. Prominence values for species from 55 to 75 m north of mineral soil along the transect through Hager Lake Fen in the outer floating mat zone (sphagnum lawn).

Distance North of Mineral Soil	55 m		60 m		65 m		70 m		75 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Spiraea douglasii	-	-	-	-	-	-	-	-	-	-
Lycopus uniflorus	6	-	-	-	-	-	-	-	-	-
Carex interior	-	-	-	-	-	-	-	-	-	-
Carex arcta	-	-	-	-	-	-	-	-	-	-
Crataegus douglasii	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-
Sphagnum spp.*	880	880	880	880	880	880	880	880	880	880
Alnus incana	-	-	-	-	-	-	-	-	-	-
Polytrichum juniperinum	-	-	-	-	-	-	-	-	-	-
Carex lasiocarpa	-	-	-	7	6	54	-	33	6	11
Potentilla palustris	-	-	-	-	-	-	-	-	-	-
Lysimachia thyrsiflora	-	3	-	-	-	-	-	-	-	-
Agrostis scabra	-	-	-	-	-	-	-	-	-	-
Viola palustris	-	-	-	-	-	-	-	-	-	-
Epilobium angustifolium	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	-
Juncus ensifolius	-	-	-	-	-	-	-	-	-	-
Menyanthes trifoliata	59	45	-	15	9	27	95	40	9	49
Kalmia microphylla	150	60	-	27	-	19	-	6	330	116
Amelanchier alnifolia	-	-	-	-	-	-	-	-	-	-
Lycopodium annotinum	-	-	-	-	-	-	-	-	-	-
Drosera anglica	240	116	160	17	60	3	50	-	-	-
Drosera rotundifolia	-	160	3	80	-	170	31	80	11	130
Scheuchzeria palustris	130	240	22	150	120	160	142	130	-	290
Viola macloskeyi	6	-	-	-	-	-	-	-	30	-
Hypericum majus	-	-	-	-	-	-	-	-	-	-
Lycopodium inundatum	-	-	-	-	-	-	-	-	-	-
Vaccinium oxycoccos	130	160	130	180	130	170	110	170	-	150
Carex rostrata	98	-	-	-	-	16	-	-	500	71
Eleocharis pauciflora	-	-	-	-	-	-	-	-	-	-
Carex limosa	240	170	310	170	380	104	330	130	-	38
Eriophorum chamissonis	-	-	-	-	-	-	-	-	-	-
Epilobium palustre	-	-	-	-	-	-	-	-	-	-
Spiranthes romanzoffiana	3	-	-	-	-	-	-	-	-	-
Eriophorum gracile	-	-	57	-	3	-	-	-	-	-
Carex canescens	-	-	-	-	-	-	-	-	-	-
Cystopteris fragilis	-	-	-	-	-	-	-	-	-	-
Pellia epiphylla	-	-	-	-	-	-	-	-	-	-
Calliergon stramineum	?	30	?	19	?	30	?	30	?	110

* = Sphagnum angustifolium and S. subsecundum
? = not included by Rumely (1956)

Table 8. Prominence values for species from 75 to 100 m north of mineral soil along the transect through Hager Lake Fen, including the middle high-hummock zone and the lake margin low-hummock floating mat zones.

Distance North of Mineral Soil	75 m		80 m		85 m		90 m		95 m		100 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Spiraea douglasii	-	-	-	-	-	-	-	-	6	-	-	-
Lycopus uniflorus	-	-	-	-	5	-	38	-	150	-	57	3
Carex interior	-	-	-	-	-	-	-	-	-	-	11	32
Carex arcta	-	-	-	-	-	-	-	-	-	-	-	-
Crataegus douglasii	-	-	-	-	-	-	-	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-	-	-
Sphagnum spp.*	880	880	880	750	750	880	850	830	800	880	880	880
Alnus incana	-	-	-	-	-	-	-	-	-	-	-	-
Polytrichum juniperinum	-	-	-	-	3	-	-	-	-	-	-	-
Carex lasiocarpa	6	11	-	-	-	-	-	-	92	11	290	150
Potentilla palustris	-	-	51	-	9	-	125	-	67	-	5	4
Lysimachia thyrsiflora	-	-	-	-	11	-	-	-	-	-	-	6
Agrostis scabra	-	-	-	-	-	-	-	-	-	-	-	-
Viola palustris	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium angustifolium	-	-	-	-	-	-	-	-	-	-	-	-
Dulichium arundinaceum	-	-	-	-	-	-	-	-	-	11	-	4
Juncus ensifolius	-	-	-	-	-	-	-	-	-	-	-	-
Menyanthes trifoliata	9	49	104	3	9	104	84	27	17	54	100	150
Kalmia microphylla	330	116	300	110	470	360	480	71	170	140	220	150
Amelanchier alnifolia	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium annotinum	-	-	-	-	-	-	-	-	-	-	-	-
Drosera anglica	-	-	-	-	-	-	-	-	-	-	-	11
Drosera rotundifolia	11	130	-	50	-	33	27	31	140	104	360	110
Scheuchzeria palustris	-	290	-	240	-	360	-	310	13	430	3	290
Viola macloskeyi	30	-	18	-	18	-	4	3	47	6	30	54
Hypericum majus	-	-	-	-	-	-	-	-	-	-	-	-
Lycopodium inundatum	-	-	-	-	-	-	-	-	-	-	11	-
Vaccinium oxycoccos	-	150	-	80	-	150	-	100	-	270	-	200
Carex rostrata	500	71	410	6	510	54	630	9	330	-	-	-
Eleocharis pauciflora	-	-	-	-	-	-	-	-	-	-	-	-
Carex limosa	-	38	-	6	-	-	-	11	-	-	-	71
Eriophorum chamissonis	-	-	-	3	-	-	-	-	-	-	-	-
Epilobium palustre	-	-	3	-	4	-	-	-	-	-	-	-
Spiranthes romanzoffiana	-	-	-	-	-	-	-	-	-	-	-	-
Eriophorum gracile	-	-	-	-	-	-	-	3	-	-	-	-
Carex canescens	-	-	-	13	-	4	-	77	-	-	-	-
Cystopteris fragilis	-	-	-	-	3	-	-	-	-	-	-	-
Pellia epiphylla	-	-	-	-	-	-	3	-	-	-	-	-
Calliergon stramineum	?	110	?	77	?	77	?	152	?	39	?	85

* = Sphagnum angustifolium, S. centrale, S. teres
? = not included by Rumely (1956)

Table 9. Prominence values for species from 20 m south of "G" (northern lake shore in 1952) to 5 m north of "G" in the littoral and lake margin zones along the transect on the north side of Hager Lake.

Distance from "G" (South to North)	20 m		15 m		10 m		5 m		At "G"		5 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Nuphar polysepalum	285	-	-	620	-	148	-	3	-	13	-	-
Brasenia schreberi	340	-	13	-	-	-	-	-	-	-	-	-
Potamogeton natans	93	-	38	-	21	-	62	-	6	-	-	-
Scirpus acutus	-	-	150	-	95	40	3	85	-	38	-	-
Dulichium arundinaceum	-	-	-	-	125	13	460	39	-	13	-	-
Eleocharis palustris	-	-	-	-	27	3	-	-	-	-	-	-
Lycopus uniflorus	-	-	-	-	-	-	-	25	-	66	9	-
Viola macloskeyi	-	-	-	-	-	-	-	5	-	60	-	-
Lysimachia thyrsiflora	-	-	-	-	-	-	-	3	-	38	-	6
Potentilla palustris	-	-	-	-	-	-	3	5	-	-	-	-
Carex limosa	-	-	-	-	-	-	-	4	-	-	-	-
Carex interior	-	-	-	-	-	-	-	3	-	6	-	-
Sphagnum subsecundum	-	-	-	-	-	-	-	70	-	300	19	4
Carex lasiocarpa	-	-	-	-	-	-	27	340	750	310	16	-
Spiraea douglasii	-	-	-	-	-	-	-	6	-	28	880	850
Pellia epiphylla	-	-	-	-	-	-	-	-	-	22	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	30	-	-
Hypericum majus	-	-	-	-	-	-	-	-	-	21	-	-
Trientalis arctica	-	-	-	-	-	-	-	-	-	-	49	-
Pinus contorta	-	-	-	-	-	-	-	-	-	-	-	28
Amelanchier alnifolia	-	-	-	-	-	-	-	-	-	-	-	3
Polytrichum juniperinum	-	-	-	-	-	-	-	-	-	-	-	78
Calliergon stramineum	?	-	?	-	?	-	?	-	?	6	?	3

? = not included by Rumely (1956)

Table 10. Prominence values for species from 5 to 465 m north of "G" (northern lake shore in 1952) along the transect through Hager Lake Fen in the Spiraea douglasii thicket and S. douglasii/Carex lasiocarpa carr north of Hager Lake.

Distance North of "G"	5 m		10 m		15 m		45 m		75 m		105 m		135 m		165 m		195 m		225 m		255 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92
Spiraea douglasii	880	850	830	880	200	850	190	850	133	880	107	580	125	450	160	290	109	450	150	310	170	750
Carex lasiocarpa	16	-	3	-	800	-	730	6	800	104	850	210	730	150	700	170	750	200	800	360	800	50
Polytrichum juniperinum	-	78	13	5	-	13	-	98	-	93	-	145	6	-	-	-	-	-	-	4	-	600
Pinus contorta	-	28	-	80	-	-	-	393	-	190	-	36	-	-	-	-	-	-	-	-	-	-
Lycopus uniflorus	9	-	38	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	13
Sphagnum subsecundum	19	4	-	6	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia thyrsiflora	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trientalis arctica	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amelanchier alnifolia	-	3	-	3	-	-	-	-	-	3	-	-	-	-	-	-	-	3	-	-	-	-
Potentilla palustris	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex interior	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia microphylla	-	-	-	-	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium angustifolium	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis scabra	-	-	-	-	-	-	-	3	-	6	-	7	-	3	-	3	-	15	-	7	-	-
Hieracium albiflorum	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum majus	-	-	-	-	-	-	-	-	-	-	-	3	-	45	-	-	-	-	-	-	-	17
Equisetum fluviatile	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Salix geyeriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	3	-	-	-
Cirsium vulgare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Aster occidentale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-

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Phleum pratense -
\- 80
Potentilla norvegica - - - - - - - - - - - - - - - - - - -
\- - 44
Trifolium repens -
\- 3
Galium trifidum -
\- -
Senecio hydrophiloides - - - - - - - - - - - - - - - - - - -
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Agrostis stolonifera - - - - - - - - - - - - - - - - - -
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Carex rostrata -
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Carex arcta -
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Carex vesicaria -
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Geum macrophyllum -
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Mentha arvense -
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Veronica scutellata - - - - - - - - - - - - - - - - - -
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Epilobium glandulosum - - - - - - - - - - - - - - - - - -
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Carex subfusca -
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Prunella vulgaris -
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Populus tremuloides - - - - - - - - - - - - - - - - - - -
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Viola orbiculata -
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Calamagrostis canadensis - - - - - - - - - - - - - - - - - - -
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Alnus incana -
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Calliergon stramineum ? 3 ? - ? - ? - ? - ? - ? - ? - ? - ? - ?
\- ? -

? = not included by Rumely (1956)

Table 10 continued.

Distance North of "G"	285 m		315 m		345 m		375 m		405 m		435 m		465 m	
Year	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92	'52	'92

Spiraea douglasii	237	750	710	54	830	230	563	11	750	161	-	9	-	100
Carex lasiocarpa	700	18	250	13	28	9	13	-	-	-	-	4	-	-
Polytrichum juniperinum	-	600	-	67	-	32	-	125	-	680	-	-	-	206
Pinus contorta	-	-	-	-	-	-	-	-	-	-	-	-	-	721
Lycopus uniflorus	-	-	-	4	-	-	-	-	-	-	-	-	-	-
Sphagnum subsecundum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lysimachia thyrsiflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trientalis arctica	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amelanchier alnifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potentilla palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drosera rotundifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex interior	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalmia microphylla	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium angustifolium	-	3	-	-	-	3	-	-	-	-	-	-	-	-
Agrostis scabra	-	5	-	50	-	9	-	3	-	150	-	-	-	67
Hieracium albiflorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypericum majus	-	-	-	25	-	-	-	-	-	-	-	-	-	3
Equisetum fluviatile	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix geyeriana	-	-	45	-	-	-	80	-	13	-	-	-	-	-
Cirsium vulgare	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Aster occidentale	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phleum pratense	-	80	-	360	-	6	-	104	-	180	-	-	-	-
Potentilla norvegica	-	6	-	3	-	7	-	-	-	3	-	-	-	3
Trifolium repens	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Galium trifidum	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Senecio hydrophiloides	22	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis stolonifera	13	-	-	3	-	4	-	4	-	-	-	-	-	-
Carex rostrata	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Carex arcta	-	-	-	5	-	800	-	700	-	360	-	880	-	360
Carex vesicaria	-	-	-	3	-	116	-	39	-	3	-	16	-	6
Geum macrophyllum	-	-	-	-	6	-	-	-	-	-	-	-	-	-
Mentha arvense	-	-	-	-	-	4	-	-	-	-	-	-	-	-
Veronica scutellata	-	-	-	-	-	15	-	-	-	-	-	-	-	-
Epilobium glandulosum	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Carex subfusca	-	-	-	-	-	-	13	-	-	3	-	-	-	-
Prunella vulgaris	-	-	-	-	-	-	6	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	28	-	-	-	-	-
Viola orbiculata	-	-	-	-	-	-	-	-	6	-	-	-	-	-
Calamagrostis canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	18
Alnus incana	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Calliergon stramineum	?	-	?	-	?	-	?	11	?	54	?	4	?	13

? = not included by Rumely (1956)