decomposed at a rate greater than that for soil organic matter as a whole. Chlorophyll derivatives, however, are highest in the L_2 and F layers, so that they are decomposed at less than the overall rate between the L_1 and L_2 litter layers. This may be so from the time the leaves fall, since freshly fallen leaves show a lower concentration of chlorophyll derivatives per unit organic matter than any of the soil layers.

Data for green and brown leaves indicate that concentrations of all three types of pigment decline very sharply before leaf fall. Leaves overwintering on oak trees exhibit a striking decline in chlorophyll derivatives, with much lower concentrations than those of the L_1 soil layers.

The relative rates of pigment decomposition are shown by ratio changes. While leaves are turning brown on the trees, chlorophylls are degraded much faster than carotenoids, as shown by a decline in CD/EC + HC ratio from 1.0 in green leaves to < 0.02 in overwintered brown oak leaves (Table 2). In the soil the situation is reversed, with chlorophyll derivatives decomposed less rapidly than carotenoids, as shown by a rise in CD/EC + HC ratio from 0.14 in freshly fallen leaves to 5.4 in the F layer of the soil. The ratio EC/HC exhibits little change, except for a drop from about 0.6 to 0.3 as leaves turn brown.

There do not appear to be any marked differences between profiles under oak and those under pine, although the ratio of chlorophyll derivatives to carotenoids is apparently somewhat higher under pine (4.6, 3.1) than under oak (2.7, 2.5). The same is true of living leaves to a lesser degree, two samples of fresh pine needles showing higher ratios (1.1, 1.1) than two samples of oak leaves (0.90, 0.89).

Pigment concentrations in the organic matter of the total woodland humus layers are compared with those of aquatic soils in Table 3. Lake muds are very much richer than the woodland soils in all three pigments, chiefly because of the anaerobic situation provided in all but the surface skin of the aquatic sediments. In the absence of oxygen, pigment degradation may be greatly inhibited in lake muds.

The high maximum pigment levels in the aquatic sediments come from very productive lakes. In these lakes a large proportion of sedimentary organic matter must come from aquatic production, since upland litter washed in from the drainage basin is bound to be very low in pigments (see Table 2).

TABLE 3. Pigment concentrations in 4 woodland soils and 31 profundal lake muds from Minnesota—expressed in units per gram organic matter

Pigment	Source	Maximum	Minimum
Chlorophyll derivatives	Terrestrial	1.2	0.6
	Aquatic	14.2	1.1
Epiphasic carotenoids	Terrestrial	0.07	0.04
	Aquatic	26.6	0.4
Hypophasic carotenoids	Terrestrial	0.24	0.16
	Aquatic	31.4	0.8

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GROUND WATER AND VEGETATION IN TWO PEAT BOGS IN NORTHERN MINNESOTA

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Abstract. Plant cover and water quality of bog waters are related to the surrounding ground-water flow systems in two bogs—one perched above and isolated from the regional ground-water system, the other nonperched and continuous with the regional system. The nonperched bog has higher pH, higher specific conductivity, and greater variety in plant cover than the perched bog.

Several studies have discussed the relationships between mineral-influenced bog waters and vegetation patterns in peatlands (Gorham 1956, Graham and Satterlund 1959, and Heinselman 1963). Others have also related pH and ionic composition directly to bog floristics (Sjörs 1950, Pierce 1953). But few have had the opportunity to relate bog-water conditions to the surrounding ground-water flow system. This has been investigated in recent

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hydrogeology studies on several bog watersheds on the Marcell Experimental Forest near Grand Rapids, Minnesota (approx. 47° 32′ N., 93° 28′ W.). Data from two bogs, S–2 and S–3 on the same forest, have helped to relate certain aspects of bog-water quality and floristics to the influence of the local ground-water regime.

The perched bog (S–2) covers about 8 acres (ca. 3.2 hectares) and was formed in a former ice-block depression. Peat depths range from less than 1 m to more than 8 m. Peat stratigraphy indicates that the bog is a typical filled lake that originally formed in a small pothole. It later progressed to a sedge meadow and finally to a site that currently supports a 70- to 100-year-old stand of black spruce (*Picea mariana* (Mill.) B.S.P.). The surrounding upland soils are developed in sandy loam to loamy fine sand material over slightly calcareous clay loam glacial till. Well logs from deep bore holes show that the till is a cap approximately 2–2.5 m thick. Below this, unstratified sands extend at least 16 m to the water table. The upland is covered with nearly mature quaking aspen (*Populus tremuloides* (Michx.)) and an understory of beaked filbert (*Corylus cornuta* Walt.).

The second nearby bog, S–3, covers approximately 28 acres (ca. 11 hectares) and has developed in a portion of another ice-block depression. Peat depths range from 1 m to over 6 m. Some aquatic peat has been found at the lower depths, but much of the upper meter is woody peat, indicating that a forest has grown in this area for at least several centuries. The surrounding mineral soils vary from well-drained fine and medium sands overlying a clay loam till to excessively drained, slightly acid, deep medium sand. The till cap does not exist over much of this area. Bore holes on ridgetops penetrated 20 m of sand before reaching the ground-water table. The upland vegetation is a mixture of nearly mature quaking aspen and jack pine (*Pinus banksiana* Lamb.).

Hydrology

The bogs differ considerably in their relationships to the general ground-water flow system. Bog S–2 is perched, with its water table approximately 8 m above the regional water table. The water table in S–2 thus reacts quite independently from the regional flow system. In fact, natural surface drainage from the bog is in a direction opposite to the slope of the regional water table.

Bog S–3, on the other hand, is part of the regional flow system and the bog water table is continuous with the regional water table. Ground water from the surrounding mineral soils recharges the bog. This influences the hydrology of the bog, the quality of its waters, and the character of the vegetative community.

Differences in the moisture regimes within the two bogs can be related directly to their water-table fluctuations, and these can be related to the influence or lack of influence of the surrounding ground-water system. Annual water-table fluctuations (particularly overwinter drawdown) are less in bog S–3, which receives continual recharge from the regional aquifer. During the growing season water-table variations are not greatly different between the two bogs because normal summer rain adds continual recharge. Because the bog water tables in both study areas are near the surface, they directly reflect evapotranspiration losses and rain recharge. However, long drying periods have less effect on bog S–3. The moisture regime has been discussed elsewhere in greater detail (Bay 1967).

Some of these hydrologic differences have been recognized by Russian engineers and were considered in the planning of reclamation works (Ivitskii 1954).

Water Quality and Temperature

The long-term hydrologic studies also included periodic measurements of certain water-quality factors. Water samples were collected on each bog at monthly intervals during the 1964 growing season. The sampling sites were recording wells—one near the center of each bog. The pH of each sample was determined in the laboratory with a Beckman Zeromatic pH meter. Specific conductivity was determined with an Industrial Instruments Model RA–2A conductivity meter. This provided an indication of total salt concentration after correction for hydrogen ions.

The influence of mineral-enriched ground water in S–3 can readily be seen in Table 1. Bog S–2 is recharged primarily from precipitation, which is relatively low in nutrients. This is reflected in lower pH and specific conductivity.

Table 1. Water quality in two types of bogs, perched (S–2) and ground-water influence (S–3)

Month (1964)	pH		Conductivity (micromhos)[a]	
	S-2	S-3	S-2	S-3
May	4.2	5.9	16.5	44.5
June	4.5	6.1	38.7	77.0
July	4.6	6.3	27.3	75.0
August	4.7	6.7	46.5	133.0
October	4.6	6.5	17.3	70.5
November	4.6	6.4	29.8	120.4

[a]Corrected for hydrogen-ion concentration as given by Sjörs (1950).

Weekly soil-temperature data were collected in each bog, also as part of the long-range hydrologic instrumentation. Bi-metal, dial-type thermometers were used to measure temperatures approximately 15 cm below the surface at each well site. This corresponded with the bog water table during the summer season. Several years of records indicated that seasonal temperature trends are nearly identical in both bogs. Maximum soil temperatures reached approximately 15°C by late July or early August each year.

Although temperatures were not recorded during winter, several general observations have emphasized the influence of the regional ground-water flow system in bog S–3. Unfrozen water was found in certain places at the bog surface each winter, although air temperatures reached −35°C and below. A water sample taken from one of these locations during midsummer indicated a conductivity of 200 micromhos. These observations indicate that certain areas are apparently being supplied with ground water through some type of channel system. Such open water holes are generally found several hundred feet from the bog edge even though the surrounding peat soils are frozen. This condition has not been found in bog S–2 or in any other perched bog under study.

Floristics

Differences in the floristics in bogs S–2 and S–3 are quite evident. S–2 contains a uniform stand of black spruce of rather low site quality. Tree diameters average 10–12 cm at breast height, and total heights are generally under 13 m. The only shrub species are scattered low-growing Ericaceae—primarily *Ledum groenlandicum* Oeder, *Chamaedaphne calyculata* var. *angustifolia* (Ait.) Rehd., *Andromeda glaucophylla* Link, *Kalmia polifolia*

Wang, and *Gaultheria hispidula* (L.) Bigel. A few forbs and grasses are also present—*Clintonia borealis* (Ait.) Raf., *Sarracenia purpurea* L., and *Eriophorum* L. The surface cover is primarily *Sphagnum* with several other mosses and mosslike plants, such as *Aulacomnium palustre* (Web. and Mohr.) Schw. and *Polytricum juniperinum* Hedw.

The vegetation in bog S–3 is more diverse and contains some plants found only on fertile sites. Besides black spruce, it has thickets of balsam fir (*Abies balsamea* (L.) Mill.) reproduction, scattered northern white-cedar (*Thuja occidentalis* L.) and paper birch (*Betula papyrifera* Marsh), and a number of large stumps and snags of tamarack (*Larix laricina* (Du Roi) K. Koch). Black spruce is still the dominant species and has attained diameters of 14–25 cm and total heights of 15–18 m at an age similar to that in S–2 (70–100 years). Very few Ericaceae are present, but there are a number of scattered thickets of several high shrubs, such as *Cornus stolonifera* Michx. and *Alnus rugosa* (Du Roi) Spreng.

A greater variety and abundance of ground plants are also present on the bog S–3 site—*Coptis groenlandica* (Oeder) Fern., *Cornus canadensis* L., *Frageria virginiana* Duchesne, and *Clintonia borealis* (Ait.) Raf. Ferns such as *Dryopteris spinulosa* (O. F. Muell) Watt, *D. cristata* (L.) Gray, and *Athyrium filixfemina* (L.) Roth are plentiful, as well as several grasses, including *Calamagrostis canadensis* (Michx.) Nutt. and *Cinna latifolia* (Trev.) Griseb. The moss surface consists mostly of *Calliergonella schreberi* (BSG) Grout., *Hylocomium splendens* (Hedw.) B.S.G., and numerous species of *Sphagnum.*

The abundance and variety of ferns, grasses, and other low-growing vegetation, and particularly the high shrubs *Cornus* and *Alnus,* are indicative of a better quality site for tree growth in bog S–3. This is similar to the black spruce-alder-herb forest described by Heinselman (1963). As a measure of stand productivity, site index, or the height reached by the average dominant and codominant trees in relatively pure, even-aged, and well-stocked stands at age 50 years, was determined from height and age measurements and site index curves (Gevorkiantz 1957). The values for S–3 and S–2, respectively, were 47 and 30, corresponding to a good and a poor-to-medium site for black spruce.

As a measure of stand density, basal area per acre in trees 9 cm dbh and over was measured as 122 ft^2 (11.3 m^2 per hectare) in S–3 and 102 ft^2 (9.5 m^2 per hectare) in S–2. The forest stand in the ground-water-fed bog is thus denser and faster growing than in the stand in the perched bog. P'yavchenko (1957) has also recognized the higher productivity of ground-water-influenced bogs.

Conclusion

Hydrogeologic investigations of four other perched bogs have revealed water quality and vegetative communities similar to those of bog S–2. The continuous ground-water flow from the surrounding mineral soil apparently greatly influences floristics in bog S–3. This richness of vegetation was not found in any perched bog. Inspection of bog vegetation may reveal some bog–ground water relationships even before exploratory bore holes are drilled in surrounding upland areas.

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MORTALITY STATISTICS OF YOUNG BATS

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Abstract. Young free-tailed bats, *Tadarida brasiliensis mexicana,* fall to the floor of nursery caves where they are eaten by beetles and predators. The number of young falling is correlated with the number of young in the cave and the bat's age. During the first two months of life there is a loss of 1.3% of the population. This mortality is lower than for the adults over a comparable period.

Introduction

Virtually nothing is known about the mortality of young bats before they can fly. This is not surprising since nursery colonies are often inaccessible. However, the roosts of many species do not appear to impose unusual stresses which would result in the death of the young bat. This is not the case for the nursery caves of the Mexican free-tailed bat, *Tadarida brasiliensis mexi-*