# 1

# A LIMNOLOGICAL INTRODUCTION TO MIRROR LAKE

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Mirror Lake is a clear-water lake in the Hubbard Brook Valley of the White Mountains of New Hampshire. This beautiful lake has had several names, including Hobart's Pond, McLellan's Pond, Jobert's Pond, Hubbard's Pond, and Tannery Pond, since white settlers colonized the area in the middle 1700s. But on a crisp, clear morning, it is easy to see why this lake has its current name. It reflects its surroundings with the perfection of an expensive mirror (Fig. 1-1). The cultural history of the lake and its drainage basin is interesting and diverse and has included small farms; family, children's, and church camps; a dance hall; a "sugar bush"; a soda bottling operation; saw mills; and a large tannery (Likens 1972; Likens 1985c, pp. 72–83).

Mirror Lake's size and depth are as follows (Table 1-1, Fig. 1-2):

| | |
|---|---|
| Maximum effective length | 610 m |
| Average depth | 5.75 m |
| Maximum effective width | 370 m |
| Length of shoreline | 2.247 km |
| Area | 15.0 ha |
| Shore development | 1.64 |
| Maximum depth | 11.0 m |
| Volume development | 1.57 |
| Relative depth | 2.5% |

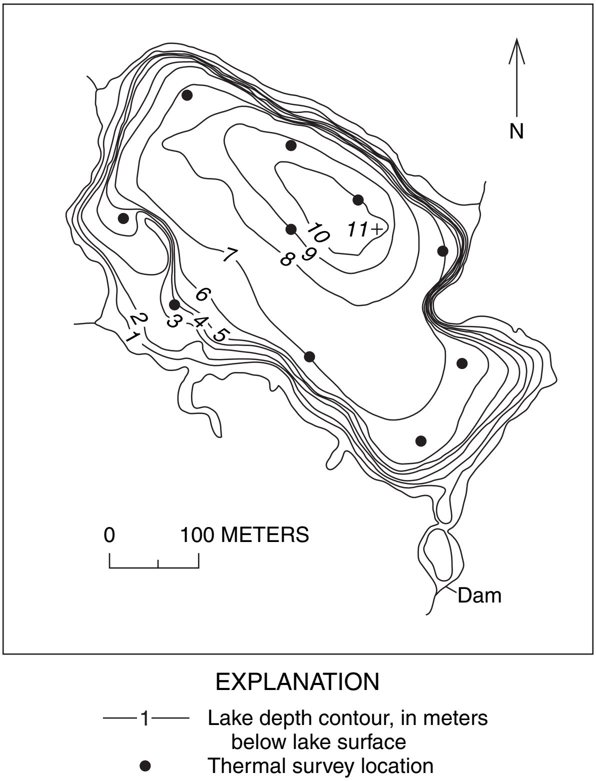
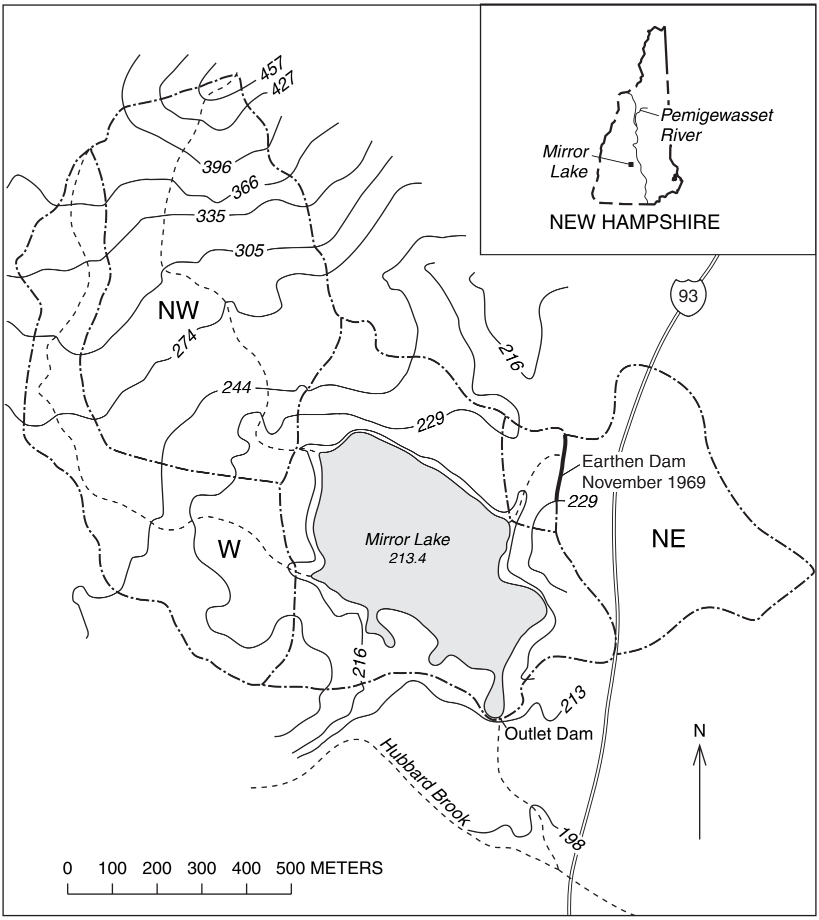



FIGURE 1-2. Bathymetric map of Mirror Lake and locations of thermal surveys. 43°56.5'N, 71°41.5'W. (From Likens et al. 1985, p. 90.)

The single outlet is dammed, but at high lake stages, flow over the dam drains into Hubbard Brook, near the mouth of the Hubbard Brook Valley. Three tributaries flow into the lake from a drainage basin of 103 ha (Winter 1985, pp. 40–53). These streams are simply called NE Tributary, NW Tributary, and W Tributary (Fig. 1-3).

Glacial deposits cover most of the watershed and underlie most of the lake's sediment. A knob of local bedrock (highly variable schist) is exposed along the northeastern shoreline and serves currently as the "swimming rock" for the lake. The maximum relief of the watershed is 268 m.

The climate is humid continental with about 1.4 m of precipitation a year, some 30 percent of which is received as snow. Summer, although




EXPLANATION

- · — · — Surface-water divide
- - - - - Trace of main tributary channel
— 198 — Land-surface contour—shows altitude of the land surface, in meters above sea level

FIGURE 1-3. Outline of Mirror Lake watershed, showing tributaries, subwatershed boundaries, and Interstate 93. 43°56.5'N, 71°41.5'W. The structure on the Northeast Tributary is an earthen dam built prior to the construction of I-93. (From Likens 1985c, p. 81.)

short, is usually hot, and winter, although long, is cold and snowy (Likens 1985a; Likens and Bormann 1995).

In 1969–1971, an interstate highway (I-93) cut through the NE drainage basin of Mirror Lake, diverting the drainage water from about 18 ha of that subdrainage of the lake and thereby reducing the total surface drainage area for the lake to 85 ha (Fig. 1-3). The ecological impact of this interstate highway on the lake and its watershed has been primarily twofold: (1) reduction in water input via the NE Tributary and (2) large input of NaCl as contamination from road salt added to I-93 during the winter for snow and ice removal (Bormann and Likens 1985, pp. 436–444; Rosenberry et al. 1999; Kaushal et al. 2005).

The lake formed from an ice block, a remnant of the retreating glacier. This ice block, buried in the glacial deposits, melted some 14,000 years ago, leaving a depression in the land surface, which then filled with water (Likens and Davis 1975; Davis 1985, pp. 53–65). Currently, Mirror Lake contains some 860,000 $m^3$ of water (Table 1-1). Water in Mirror Lake is relatively clear and nutrient poor, and is therefore considered oligotrophic (<2 μg/liter chlorophyll-*a*). Its "high quality" is prized for recreation during the summer, especially for swimming. There is a public beach (Town of Woodstock) on the south shore; boating and fishing are popular, but no gasoline-powered motors are allowed on the lake.

Currently, there are 11 "permanent" residences and a Hamlet of cabins in the Mirror Lake watershed. There are nine housing units in the Hamlet. During the 1980s, about half of the shoreline (northern shore) was purchased for protection against development and currently is owned by the USDA Forest Service. In 2004 the Mirror Lake Hamlet area (southwestern shore) was purchased for shoreline protection, research access, and provision of housing for researchers of the long-term Hubbard Brook Ecosystem Study being done within the Hubbard Brook Valley. Thus, about 70 percent of the shoreline area of Mirror Lake has been protected from further development since 2004.

## LIMNOLOGICAL HISTORY OF THE LAKE

Mirror Lake slowly began to fill with sediment some 14,000 years B.P. (before present), when the lake formed. It is estimated from numerous cores of the lake's sediment that the original basin had a maximum depth of about 24 m (Davis and Ford 1985). Thus, the volume of water in the lake today is roughly half of what it was 14,000 years B.P., assuming the water surfaces were similar in ancient and modern times.

A scarcity of charcoal in the sediment profile suggests a relatively low occurrence of fire in the drainage basin during the lake's history. Somewhat more charcoal was accumulated in the sediments 8000 to 7000 years B.P., which correlates with a greater abundance of fire-prone, coniferous vegetation in the landscape at that time (Davis 1985).

From 14,000 to about 200 years B.P., the chemistry and productivity of Mirror Lake changed relatively little (see chapter 6). The lake was cold and relatively unproductive, and the pH was about circumneutral during much of this period. However, the watershed changed appreciably during this time, from a tundra-like landscape, following the retreat of the glacier, to one characterized by coniferous vegetation (e.g., increase in spruce [*Abies* sp.] some 2000 years B.P.), and more recently to one dominated by deciduous vegetation (Davis 1985). Recent human settlement (since about 200 years B.P.) resulted in more rapid changes in chemistry and biology of the lake (see chapter 6). For example, concentrations of cadmium, zinc, lead, iron, and manganese recently have increased in the sediment profile in the lake (Likens and Moeller 1985, pp. 392–410; Sherman 1976). Presumably, the increases in toxic metals in recent sediments are the result of human activities in the lake's watershed and airshed.

## THE LAKE TODAY

### PHYSICAL LIMNOLOGY

The duration of ice cover on Mirror Lake has become significantly shorter since 1968 (Figs. 1-4 and 1-5; chapter 6). This shortening is correlated with an increase in average air temperature during April of each year (Likens 2000). Because the ice cover on a lake is directly related to its energy budget, changes in duration of the ice cover have been related to regional/global warming (Likens 2000; Magnuson et al. 2000). Generally, the ice cover on Mirror Lake is 40 to 75 cm thick by February, and there may be appreciable snow on it as well (Johnson et al. 1985, pp. 108–127).

Normally, the lake circulates completely ("overturns") throughout the basin twice (dimictic) a year—in spring after the ice cover melts and

FIGURE 1-4. Ice melting on Mirror Lake in April 2002. (Photo by Donald Buso.)

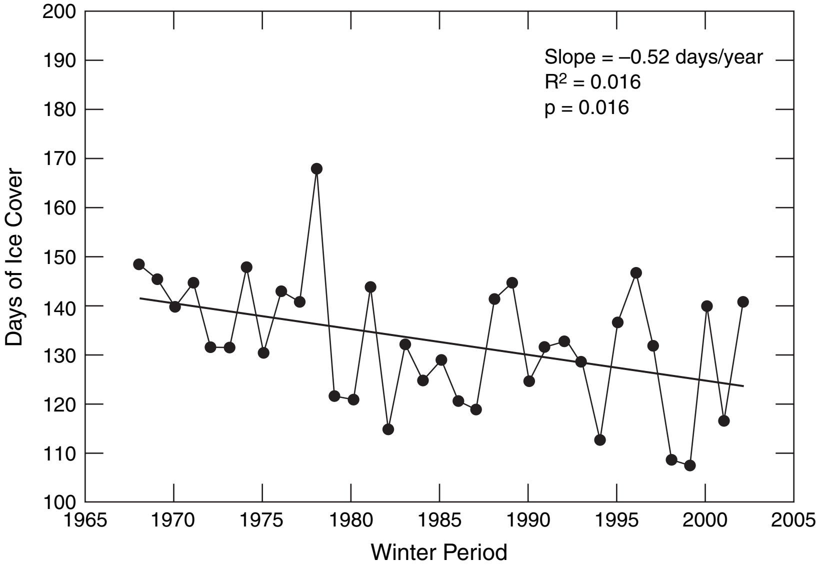



FIGURE 1-5. Long-term record of ice-cover duration on Mirror Lake. (Modified and updated from Likens 2000.)

in fall before the ice cover forms. At these times, the density of water is similar from top to bottom, and the work of the wind acting on the surface of the lake can relatively easily mix the water throughout the entire basin. The lake does not circulate completely during the summer and winter (ice-cover) periods, when the lake is thermally stratified (i.e., has large density differences from top to bottom)(Fig. 1-6; see Johnson et al. 1985, pp. 108–127). The lake is slightly undersaturated with respect to dissolved oxygen and is anoxic below about 8 m during late-summer stratification periods. As the period of ice cover decreases as a result of global warming, the time of summer stratification potentially will be lengthened. As a result, it is likely that anoxia in the hypolimnion will be intensified, with many potential ecological ramifications. These changes in response to global warming are the subject of ongoing investigation.

The theoretical flushing time for water in the lake is about one year, but cold, incoming surface water during the snowmelt period in the spring, which is at a lesser density than the water in the lake, may flow under the ice and out the outlet without mixing into the total volume of the lake, increasing the actual flushing time to 15 months or more (Johnson et al. 1985, pp. 108–127). This topic will be considered in more detail in later chapters.

Water transparency, as measured by a standard (20 cm diameter) Secchi disk, is quite variable throughout the year, but the Secchi depth normally ranges from 5 to 7 m in summer and from 2.5 to 3.5 m in winter. The maximum value recorded was 8.5 m in 1979 (Likens et al. 1985, pp. 89–108). Thus, Mirror Lake is a relatively clear-water lake.

## BIOLOGICAL LIMNOLOGY

There are some 850 species of plants, animals, and microorganisms in the lake, but estimates of the number of species in some groups are highly uncertain (Table 1-2). Based on these estimates, benthic invertebrates are the most species rich and represent almost one-half of the total number of species in the lake. It should be noted, however, that appreciable effort has been expended to describe the benthic fauna of Mirror Lake (Walter 1985, pp. 204–228; Strayer 1985a, 1985b), whereas relatively little effort has been spent to describe the species richness of bacteria and fungi. Pelagic algae (phytoplankton) are the next most species-rich group (Table 1-2).

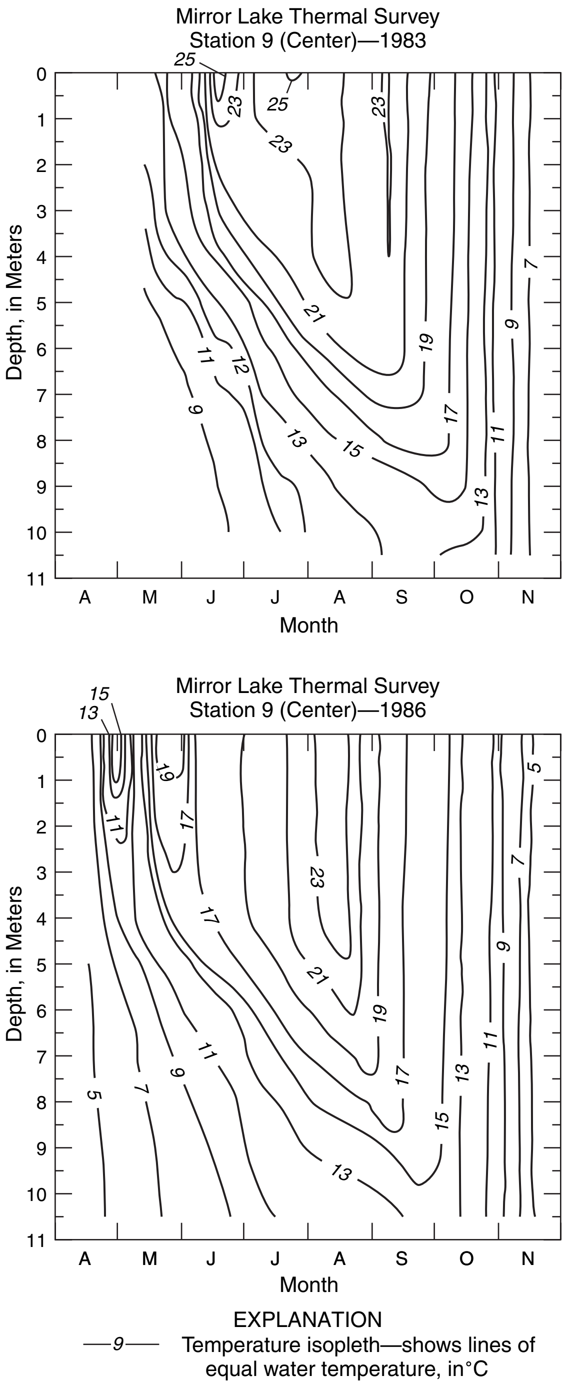



FIGURE 1-6. Depth-time temperature (°C) isopleths for a dry year (1983) and a wet year (1986).

The species diversity in Mirror Lake is not particularly high relative to other lakes. For example, Godfrey (1977) found 217 species of pelagic algae in Cayuga Lake, New York. The relatively low species richness in Mirror Lake may be due to the relatively low nutrient concentrations and slightly acidic conditions in the water, the relatively long period of ice cover, and the relative absence of macrophytes, all of which reduce habitat diversity and all of which are characteristic of oligotrophic lakes in the North Temperate Zone.

There are very few aquatic macrophytes in Mirror Lake in terms of either species or abundance (Moeller 1985, pp. 177–192). Small patches of water lilies (*Nuphar* and *Nymphaea* spp.), burr weed (*Sparganium* sp.), pipewort (*Eriocaulon* sp.), and water lobelia (*Lobelia* sp.) can be seen at the surface of the lake in summer. Below the surface, patches of bladderwort (*Utricularia* sp.), pondweeds (*Potamogeton* sp.), *Isoetes* sp., stoneworts (*Nitella* sp.), and a few other submerged plants occur. At times during the summer, bladderwort may become quite abundant in some areas of the lake. The scarcity of macrophytes in Mirror Lake may be due to the low nutrient content of the lake and the large expanses of sand, cobbles, and boulders in shallow areas (Fig. 1-7), but the definitive answer has not been determined (Moeller 1985).

Until recently, Mirror Lake contained five species of fish: smallmouth bass (*Micropterus dolomieui*), yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), white sucker (*Catostomus commersoni*), and brown bullhead (*Ictalurus nebulosus*). In addition to this low diversity, none of these species occur in large numbers (Mazsa 1973; Helfman 1985). In 1995, the New Hampshire Fish and Game Department stocked rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*) in the lake and has continued to stock rainbow trout since. As a result, the recreational fishery in the lake has increased greatly in popularity, especially in winter (Fig. 1-8).

A small population of the red-spotted newt (*Notophthalmus v. viridescens*) inhabits Mirror Lake and often can be seen in tributary areas as well (Burton 1985). These newts normally experience low predation because of toxins in their skin. Other amphibians (e.g., the green frog [*Rana clamitans*] and the American toad [*Bufo americanus*]) inhabit shoreline areas. Also, painted turtles (*Chryscarys picta*) may be seen basking, and common snappers (*Chelydra serpentina*) are found, although rarely. The common loon (*Gavia immer*), typically immature and solitary, is present, as are mallard ducks.

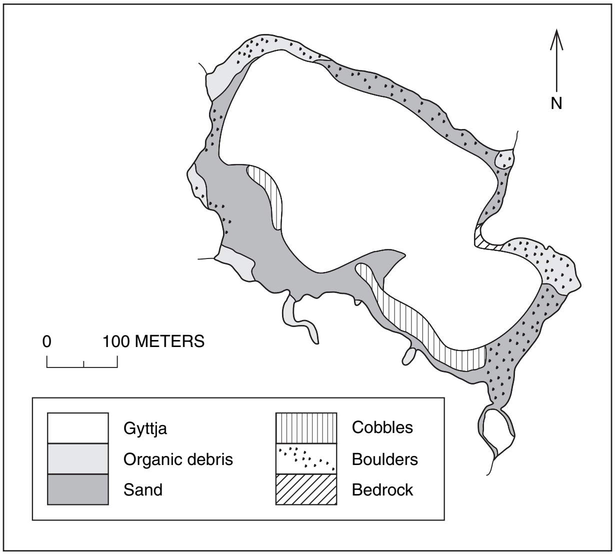



FIGURE 1-7. Distribution of lakebed sediments in Mirror Lake.

Overall, Mirror Lake is relatively unproductive. About 0.34 percent of incoming solar radiation is fixed annually by photosynthetic plants in Mirror Lake. Phytoplankton productivity accounts for about 90 percent of total plant productivity on an annual basis in Mirror Lake, as rooted macrophytes are relatively rare (Table 1-3). Some 70 percent of all inputs of organic carbon to the lake are respired by consumers (Likens 1985b).

### CHEMICAL LIMNOLOGY

The chemistry of Mirror Lake, as well as its three tributaries, is currently dominated by calcium and sulfate (Table 1-4), although concentrations of sodium and chloride have been increasing in the NE Tributary and in the lake because of road salt contamination from I-93 (see chapters 3 and 6). Concentrations of nutrients (phosphorus and nitrogen), usually limiting to biological productivity in freshwater ecosystems, are very low in Mirror Lake (Table 1-4) and co-limit biological productivity (Gerhart and Likens 1975; Bade et al. 2008). Currently, pH averages around 6.4, acid-neutralizing capacity (ANC) is 81 mg/liter, average specific conductivity is about 31 μS/cm, and average dissolved organic carbon (DOC) concentration is approximately 1.8 mg/liter (Table 1-4). A more detailed

FIGURE 1-8. So-called "ice houses" used for fishing on Mirror Lake in January 2003. (Photo by Gene E. Likens.)

analysis and a discussion of long-term trends in the lake's chemistry are presented in chapters 3 and 6.

A budgetary or mass balance approach has been used successfully for many decades as part of the Hubbard Brook Ecosystem Study to analyze biogeochemical and hydrological fluxes and change (see Bormann and Likens 1967; Likens and Bormann 1995; Likens 1992). In the most simple form, the mass balance for an ecosystem can be described as Inputs = Outputs + Δ Storage. For Mirror Lake, this equation can be expanded to

$$P + GWI + SWI + GASIN$$
$$= SWO + GWO + GASOUT + \Delta \text{ Storage} \qquad (1\text{-}1)$$

where

*P* is direct bulk precipitation on the lake's surface,

*GWI* is groundwater seepage to the lake,

*SWI* is tributary stream water,

*SWO* is flow over the dam at the lake outlet,

*GWO* is seepage of lake water to ground water,

*GASIN* and *GASOUT* are water vapor and elements in gaseous form at normal biological temperatures (e.g., $N_2$),

Storage includes long-term biological uptake and sedimentation.

All terms in Equation 1-1 are subject to uncertainty, which is considered in chapters 4 and 5. Equation 1-1 can be considered as a net ecosystem budget or balance (see Likens et al. 2002).

This approach has been used to estimate ecosystem parameters that are difficult to measure, such as weathering and evapotranspiration in watershed ecosystems of the Hubbard Brook Experimental Forest (Bormann and Likens 1967). It will be the basis for much of the analysis done in chapters 2, 3, 4, and 5.

The average standing stock of carbon, nitrogen, and phosphorus in Mirror Lake is given in Table 1-5. Most of the carbon, nitrogen, and phosphorus is located in the top 10 cm of sediment, followed by the dissolved

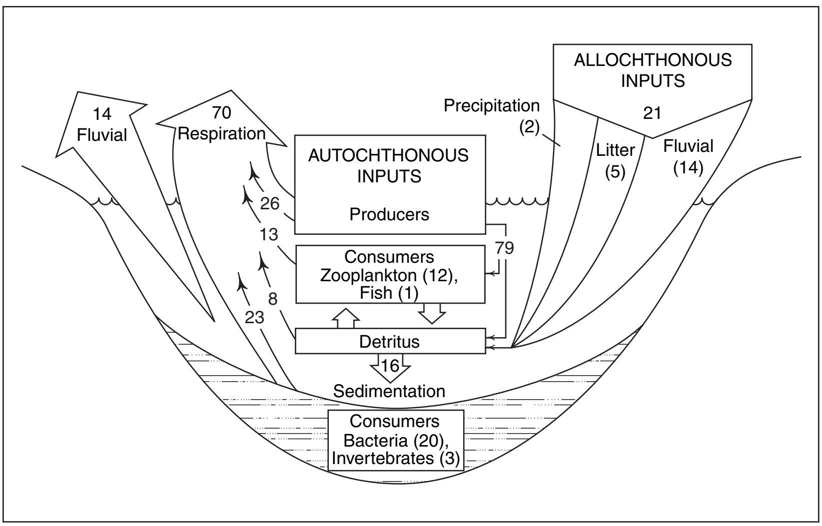



FIGURE 1-9. Food web for the Mirror Lake ecosystem. Values represent percent of organic carbon flux through Mirror Lake. Sedimentation represents net sedimentation. (From Likens 1985b, pp. 337–344.)

component. The completeness of the total phosphorus budget for Mirror Lake is unusual (Cole et al. 1990). Movement of organic carbon through the food web of Mirror Lake is diagrammed in Fig. 1-9.

## THIS BOOK

Mirror Lake has been the focus of comprehensive and continuous scientific study since 1965 and as such is one of the most studied lakes in the world. These studies led in 1985 to a comprehensive book, *An Ecosystem Approach to Aquatic Ecology: Mirror Lake and Its Environment* (Likens 1985a). Much of this book was the product of my own research, done with the help of my graduate students, postdocs, technicians, and colleagues. The geological and cultural history of Mirror Lake, as well as its ecology, paleoecology, biogeochemistry, and limnology (study of inland waters), are discussed in detail, but several of the hydrologic components (e.g., evaporation and deep seepage of ground water) were determined by approximation or difference. Here, the magnitude of these terms is determined directly.

Limnologically, Mirror Lake is very similar to many lakes in northern New England and the Precambrian Shield of Canada with respect to biogeochemistry, hydrology, and limnology (Likens 1985b). The previous book about Mirror Lake (Likens 1985a) attempted to detail many of the processes, functions, and species (biotic and abiotic) that have been identified and studied in the lake, and therefore provided a framework for understanding the lake as the sum of its working parts: an aquatic ecosystem. That effort was, in effect, a collection of linked puzzle pieces, but quantitatively, it lacked some of the edges for the completed scene. This approach seems counterintuitive, given that the easy part of any puzzle is supposed to be the edges. Here is the paradox: Ecosystems are difficult to study because defining the pieces can require much more information than can be gathered in just a few field seasons, even when focusing on central processes or critical species. Guessing at how the edges fit together leaves many important questions unsolvable. Thus, this second book is all about quantifying two critical pieces of the Mirror Lake ecosystem puzzle, the hydrology and chemistry of the lake. These components are intricately and inescapably linked to allow the ecosystem to function. Just why these pieces are important, and how they can be measured quantitatively, is the focus of this book. The quantitative evaluation of the hydrologic and chemical pieces (quantity and flux) of the lake allow more of the ecosystem puzzle to be assembled, and constrain as the matrix all other ecosystem "pieces" and functions, large or small.

This current book provides a detailed analysis of the hydrology and chemistry of this small lake and focuses on the long-term linkages among air, land, and water during 1981 to 2000, with a uniquely detailed and complete data set. Data from these long-term studies provide important insights into the function and change in this aquatic ecosystem, as well as about the lake's linkages with regional and global systems.

TABLE 1-1. *Morphometric and volumetric characteristics of Mirror Lake*

| *Depth (m)* | *Area* | | *Stratum (m)* | *Volume* | |
|---|---|---|---|---|---|
| | $m^2 \times 10^4$ | % of total | | $m^3 \times 10^3$ | % of total |
| 0 | 15.0 | 100.0 | 0–1 | 142.9 | 16.6 |
| 1 | 13.6 | 90.5 | 1–2 | 130.0 | 15.1 |
| 2 | 12.4 | 82.9 | 2–3 | 119.5 | 13.9 |
| 3 | 11.5 | 76.5 | 3–4 | 110.0 | 12.8 |
| 4 | 10.5 | 70.1 | 4–5 | 101.8 | 11.8 |
| 5 | 9.86 | 65.7 | 5–6 | 94.1 | 10.9 |
| 6 | 8.96 | 59.7 | 6–7 | 78.5 | 9.1 |
| 7 | 6.79 | 45.2 | 7–8 | 48.9 | 5.7 |
| 8 | 3.21 | 21.4 | 8–9 | 23.6 | 2.7 |
| 9 | 1.61 | 10.7 | 9–10 | 10.7 | 1.2 |
| 10 | 0.609 | 4.06 | 10–11 | 2.0 | 0.2 |
| 11 | 0 | 0 | | | |
| | | | Total | 862.0 | 100.0 |

SOURCE: Modified from Winter 1985.

TABLE 1-2. *Estimated number of species in Mirror Lake*

| *Type* | *Number of species*[a] |
|---|---|
| Pelagic algae (phytoplankton) | 138 |
| Benthic algae | >50? |
| Macrophytes | 37 |
| Pelagic bacteria | >50?? |
| Pelagic fungi | >10??? |
| Benthic bacteria | >100?? |
| Benthic fungi | >10??? |
| Pelagic zooplankton (includes Protozoa) | >50? |
| Benthic invertebrates | >400? |
| Fish | 6 |
| Reptiles and amphibians | 4–7 |
| Birds | 4–5 |
| Mammals | 2–5 |
| Total | >850 |

SOURCE: From Likens 1992.

[a] ? indicates relative uncertainty.

TABLE 1–3. *Inputs of organic carbon for Mirror Lake*

| *Source* | *Carbon ($mg\ m^{-2}\ yr^{-1}$)* |
|---|---|
| Autochthonous (gross) | |
| Phytoplankton (POC and DOC) | 56,500[a] |
| Epilithic algae | 2500[b] |
| Epipelic and epiphytic algae | >1000[b] |
| Macrophytes | 2500[b] |
| Dark $CO_2$ fixation | 2100[b] |
| | Total 64,600 |
| Allochthonous | |
| Precipitation | 1400[c] |
| Shoreline litter | 4300[c] |
| Fluvial[d] | |
| DOC | 10,500[e] |
| FPOC (0.45 μm–1 mm) | 300[e] |
| FPOC (>1 mm) | 50[e] |
| CPOC | 800[e] |
| | Total 17,350 |
| | Combined inputs 81,950 |

SOURCE: From Likens 1985b. Carbon data revised from Jordan and Likens 1975.

[a] Daytime $^{14}C$ fixation = 47,000 (POC = 38,300; DOC = 8700). Gross POC fixation = 47,800. Net POC fixation = 28,700 (60% × 47,800). Day and night respiration = 19,100 (40% × 47,800). Net POC = 0.75 × [$^{14}$C]POC. The 0.75 is a correction for nighttime respiration based on net = 60% gross + R = 10% $P_{max}$ (Steemann Nielsen 1958).

[b] Right order of magnitude.

[c] +20%.

[d] DOC = dissolved organic carbon. FPOC = fine particulate organic carbon. CPOC = course particulate organic carbon.

[e] +50%.

TABLE 1-4. *Average chemical data for Mirror Lake, 1981 to 2000 (20 years)*

| *Chemical* | *Lake[a] average* | *Lake[a] range* | *W tributary average* | *W tributary range* |
|---|---|---|---|---|
| Calcium | 2.39 | 3.47–0.73 | 2.62 | 6.57–1.27 |
| Sodium | 2.11 | 3.53–0.66 | 2.36 | 5.87–0.95 |
| Magnesium | 0.51 | 0.65–0.23 | 0.57 | 1.37–0.21 |
| Potassium | 0.46 | 0.64–0.18 | 0.54 | 1.66–0.18 |
| Ammonium | 0.02 | 0.22–0.01 | 0.02 | 0.13–0.01 |
| $H^+$ | 0.4 | 1.9–0.1 | 1.1 | 7.9–0.5 |
| Aluminum | 0.01 | 0.010–0.005 | 0.01 | 0.10–0.01 |
| Sulfate | 4.52 | 16.2–1.6 | 5.08 | 11.7–0.7 |
| Chloride | 2.86 | 5.19–1.02 | 2.65 | 7.41–0.70 |
| Nitrate | 0.04 | 0.75–0.01 | 0.16 | 2.28–0.01 |
| Phosphate | 0.009 | 0.080–0.001 | 0.009 | 0.092–0.001 |
| Dissolved silicate | 2.07 | 3.7–0.1 | 9.2 | 15.2–3.7 |
| Dissolved organic C | 1.8 | 3.4–1.5 | 3.1 | 16.2–1.0 |
| pH | 6.38 | 7.00–5.72 | 6.13 | 7.15–5.10 |
| Sp. cond. ($\mu S\ cm^{-1}$) | 31 | 45–22 | 31 | 55–16 |
| ANC | 81 | 270–7 | 90 | 341–(–13) |
| Dissolved inorganic C | 163 | 804–55 | 101 | 393–34 |
| Dissolved O (% sat) | 84 | 145–39 | N/A | — |

NOTE: Units in mg $L^{-1}$ unless noted otherwise.

[a] Lake water for depths of 2–8 m, not from surface or hypolimnion, to avoid dilution from ice melt during spring and anoxia during summer stratified periods. To convert dissolved silicate to silica, multiply by 0.47.

TABLE 1–5. *Average standing stock and ratios (weight basis) of carbon, nitrogen, and phosphorus in the Mirror Lake ecosystem*

| *Component* | *kcal × 10^3* [a] | *C (kg)* [b] | *N (kg)* [b] | *P (kg)* [b] | *C : N : P (by wt)* |
|---|---|---|---|---|---|
| Dissolved[c] | 33,600 | 3360 [d] | 124 | 2.5 | 1344 : 50 : 1 |
| Seston | 2420 | 247 [e] | 32.3 | 2.48 | 100 : 13 : 1 |
| Bacterioplankton | 120 | 12 [f] | 2.1 [g] | 0.3 [g] | 40 : 7 : 1 |
| Phytoplankton | 411 | 56 [d] | 9.8 [g] | 1.4 [g] | 40 : 7 : 1 |
| Epilithic algae | 570 | 57 [f] | 3.0 | 0.075 | 760 : 40 : 1 |
| Macrophytes | 2020 | 202 [h] | 14 | 0.8 | 252 : 17 : 1 |
| Zooplankton | 313 | 30 [d] | 4.9 | 0.84 | 36 : 5.8 : 1 |
| Fish | 408 | 36 [f] | 8.2 | 2.7 | 13.1 : 3.0 : 1 |
| Salamanders | 10 | 0.77 [h] | 0.13 | 0.055 | 14.1 : 2.4 : 1 |
| Benthic macroinvertebrates | 1050 | 105 [h] | 25.5 | 3.0 | 35 : 8.5 : 1 |
| Benthic bacteria | 6000 | 600 [f] | 105 [g] | 15 [g] | 40 : 7 : 1 |
| Sediment (top 10 cm) | 733,000 | 150,000 [d] | 10,570 | 1280 | 117 : 8.3 : 1 |

SOURCE: Modified from Likens 1985b.

[a] Computed by converting C to dry weight (C ÷ 0.45) and multiplying by mean caloric values from Cummins and Wuycheck (1971).

[b] Divide by $15 \times 10^{-4}$ to convert to kcal/m$^2$ or by 0.15 to convert to mg/m$^2$.

[c] Organic plus inorganic: DIC = 1290 kg, DOC = 2070 kg, $NH_4$-N = 21.6 kg, $NO_3$-N = 16.4 kg, organic N = 86 kg, Total $PO_4$-P = 1.7 kg.

[d] +20%.

[e] Excluding zooplankton.

[f] Right order of magnitude.

[g] Assuming a weight ratio of 40 : 7 : 1 for C : N : P.

[h] +50%.

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