Little Balsam Lake, Polk County, Sediment Core Study

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Two sediment cores was collected from Little Balsam Lake on 20 September 1988 in the center of the basin. The water depth was 6.8 m (22 ft). One core was 24 cm in length and sectioned into 1 cm intervals and the other core was 70 cm in length and sectioned into 2 cm intervals. The core was analyzed for diatoms to assess changes in nutrient levels during the last 150 years. The core was dated by the ^{210}Pb method and the CRS model (Appleby and Oldfield, 1978) used to estimate dates and the sedimentation rate.

Lead-210 is a naturally occurring radionuclide that enters the lake primarily through precipitation and dry deposition. Since this nuclide has a half-life of 22.3 years, it can be used to date samples back 130-150 years. By measuring the total amount of ^{210}Pb in the core and the amount in a sample in question, the date of this sample can be calculated. This analysis also calculates the sedimentation rate of the sample.

Diatoms frequently are the primary tool used to reconstruct a lake's water quality history in paleolimnological studies. They are particularly useful because they are taxonomically distinct and their siliceous cell walls, called frustules, are usually abundant, diverse, and well-preserved in sediments. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels.

Prior to the arrival of Europeans during the 1850's the landscape around Little Balsam Lake was oak savanna with prairie like vegetation as well as some larger forest stands. Early settlers converted the prairie landscape into agricultural uses such as subsistence farming. Later in the 19th century after the development of the moldboard plow, a larger part of the lake's watershed was plowed. This resulted in a relatively small increase in the sedimentation rate (Figure 1).

During the 1940's agriculture became increasingly mechanized which enabled the farming of more land. In many other areas of the state this resulted in an increase in the sedimentation rate of lakes as well as increased productivity. The peak sedimentation rate in Little Balsam Lake occurred in the late 1930s (Figure 2). This high sedimentation rate likely was the result agricultural activities in the watershed as well as home and other construction activities. From the period 1960-1980 the sedimentation rate was near historical levels but it showed some increase during the 1980s.

In the upper portion of the watershed is located the village of Milltown. This town was established in 1869 with a population of 66. The population increased throughout the early part of the 20th century but remained relatively small through the 1940's. In addition to waste generated by the local populace, there was also a cannery and creamery in the village. Prior to 1939, the town's wastewater was discharged into onsite septic tanks. A primary wastewater treatment plant began operation in 1939 and discharged into a marsh located near the upper part of Mill Creek.

The operation of the wastewater treatment plant resulted in the concentration of sewage into one place and following treatment, discharge of nutrients such as phosphorus and nitrogen into the marsh along

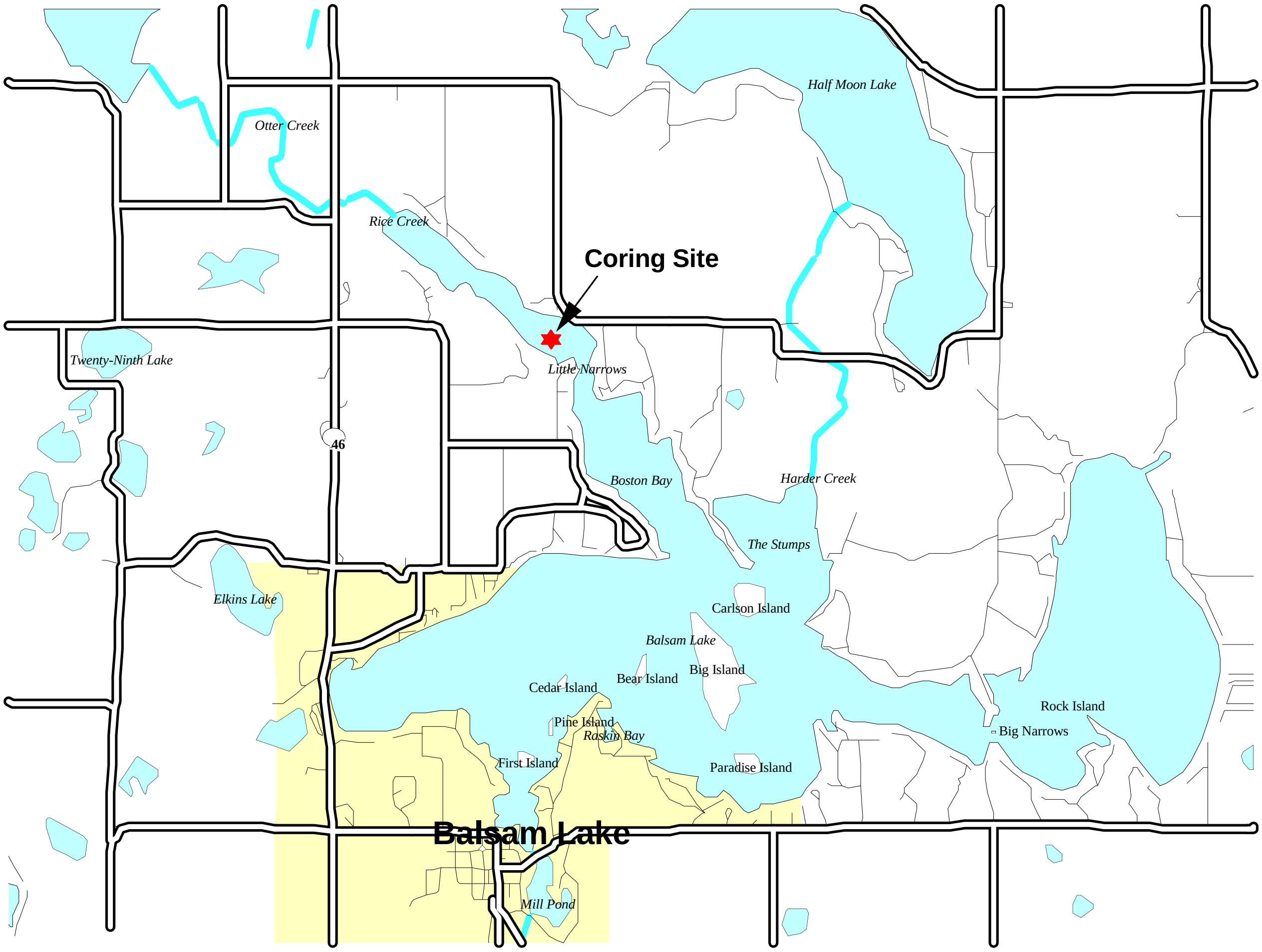


Figure 1. Map of Balsam Lake showing the coring site on Little Balsam Lake.

Mill Creek. These nutrients apparently seeped into Mill Creek and then moved downstream. The high levels of nutrients discharged from the wastewater treatment plant also adversely affected Little Balsam Lake.

The diatom assemblage indicates that Little Balsam Lake has had moderate amounts of nutrients during the last 150 years. The dominant diatom taxa throughout this period has been *Fragilaria crotonensis* and *Stephanodiscus minutulus* (Figure 3) which are indicative of nutrient rich conditions (Bradbury, 1975; Engstrom et al., 1985; Fritz et al., 1993; Christie and Smol, 1996). The diatom assemblage indicates that algal blooms probably occurred prior to the arrival of Europeans although it is likely that they were worse during the time period when 1940-1975. During this time period there was a decline in *Aulacoseira* spp. and *Tabellaria flocculosa* str. IIIp, which are indicative of lower phosphorus levels, and an increase in the high phosphorus diatom *S. minutulus* (Figure 4). The historical existence of algal blooms is not unusual in lakes like Little Balsam Lake that have a relatively large watershed. This has been observed in sediment cores from other drainage lakes throughout the state. Sufficient nutrients were discharged from the watershed even when the landscape was a prairie to cause some algal blooms.

These increased nutrients with the installation of the primary treatment plant resulted in an increase in the algal production in the lake. This is shown in Figure 4 by the increase in the diatom accumulation rate. The

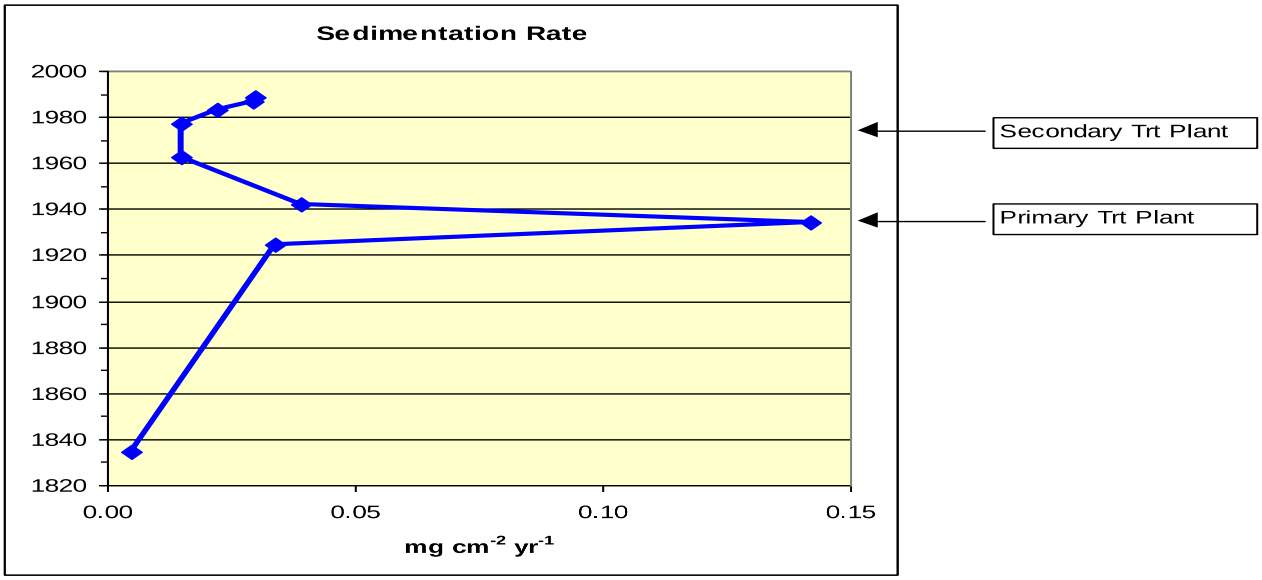
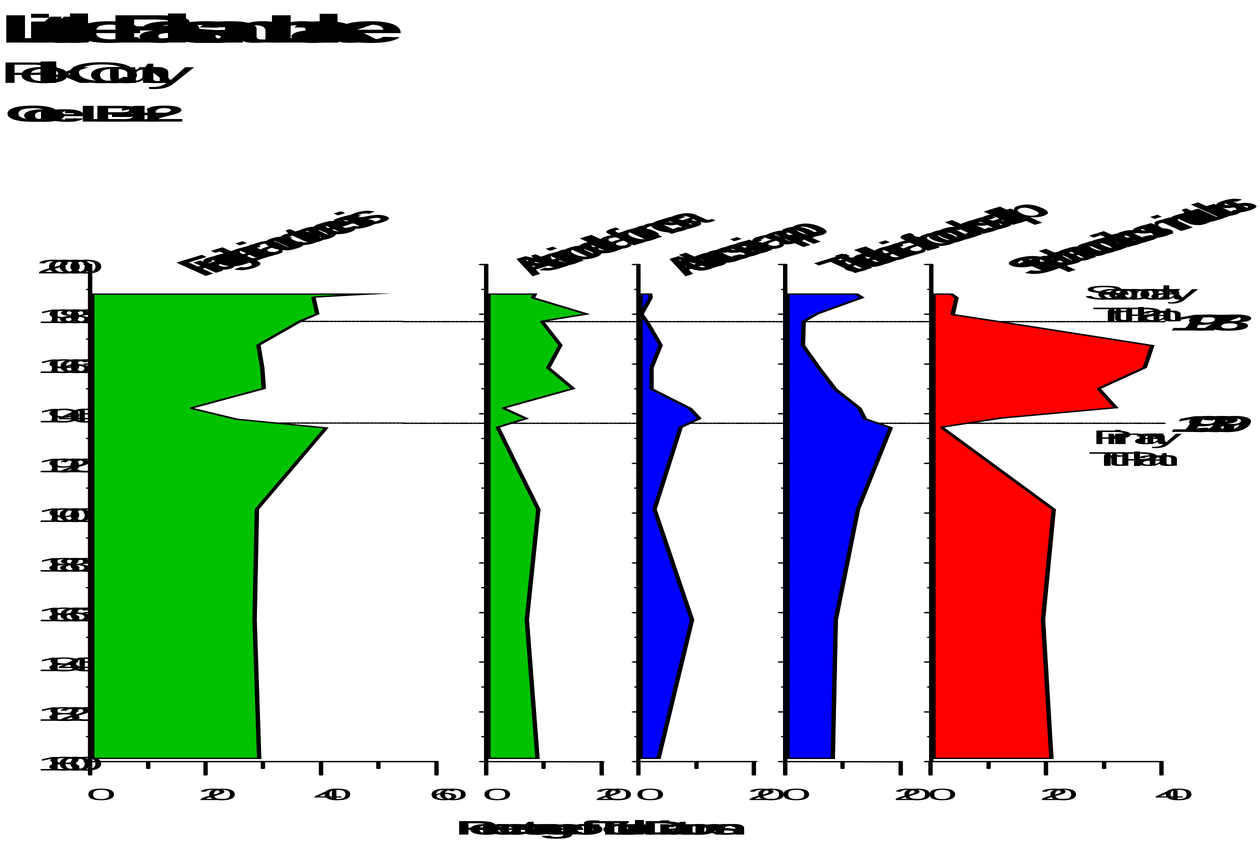


Figure 2. Bulk sedimentation rate from Little Balsam Lake sediment core. The peak sedimentation rate, which occurred in the late 1930s, was likely from agricultural activities.



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rate was very low prior to the operation of the wastewater treatment plant in 1939. Productivity began to rise and was especially high during the period from 1950-1975. This increase in algal productivity was also noted in Rice Lake, which is upstream of Little Balsam Lake. This lake became very eutrophic in the 1970's and this at least partially, led to the near elimination of wild rice from the lake.

In 1978 the Milltown sewage treatment plant was upgraded to secondary treatment. This reduced the amount of nutrients that were discharged into Mill Creek and resulted in a dramatic decrease in diatom production. This reduction in algal production also occurred in Rice Lake. The production of the green alga *Pediastrum* dramatically decreased following the upgrading of the sewage treatment plant to secondary treatment (Engel and Nichols, 1991). This reduced algal production was maintained in Little Balsam Lake during the next decade until this core was collected.

In summary, the sediment core results show that Little Balsam Lake has been productive for at least 200 years, which is not unusual given the large size of its watershed. The lake did become more eutrophic following the beginning of operation of the sewage treatment plant at Milltown. Algal productivity was highest during the period 1940-75 because of the nutrients discharged from the sewage treatment plant. When the plant was upgraded to secondary treatment in 1978, the lake's water quality greatly improved although algal blooms still occur. The core indicates that algal levels in the late 1980's were lower than was experienced in the previous 25 years. The peak sedimentation rate occurred around 1940. This most likely was not a result of the sewage treatment plant but more likely the result of other activities in the watershed such as agriculture.

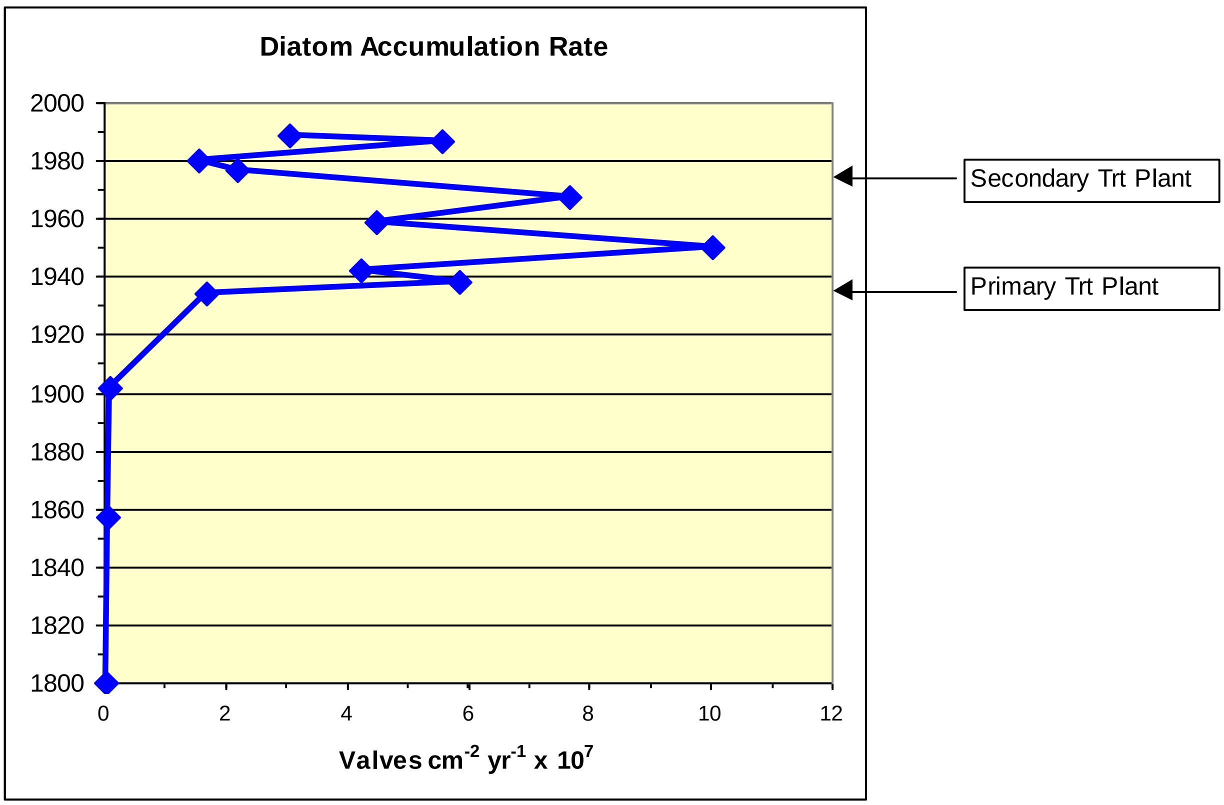

Figure 4. The diatom accumulation rate indicates changes in algal productivity in the lake. Productivity peaked during the period 1940-1975, largely as a result of discharge from the sewage treatment plant in Milltown. When this plant was upgraded in 1978, fewer nutrients were discharged.

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