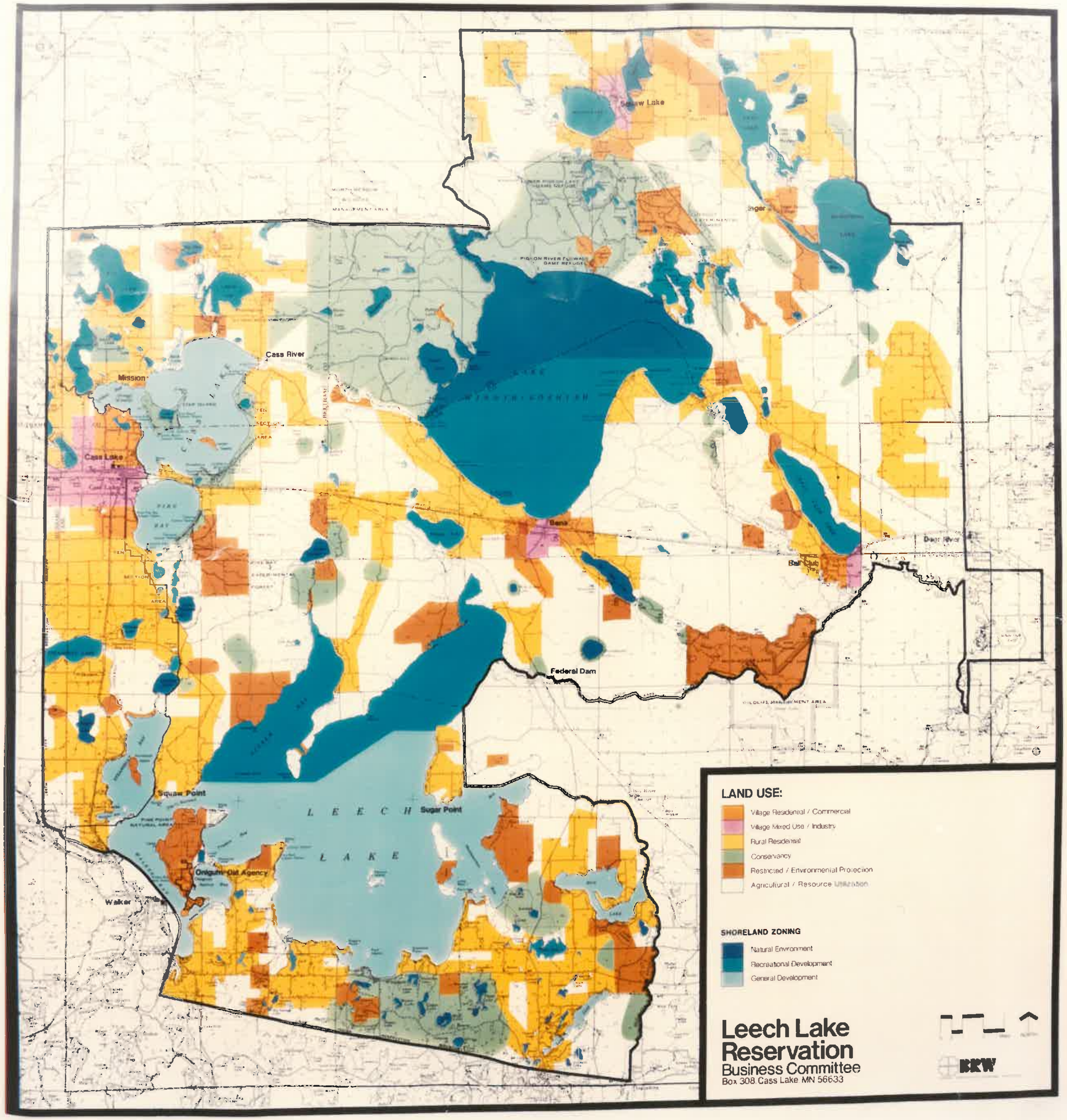
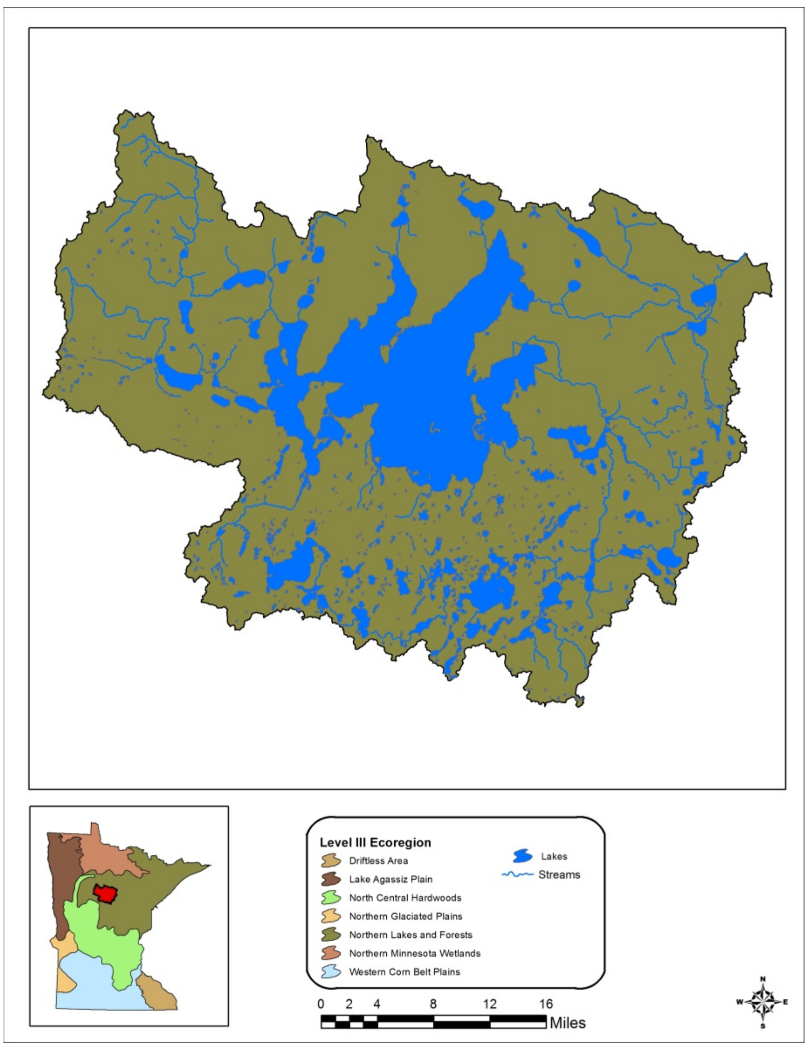

Squaw Lake
Inger
Cass River
Mission
Cass Lake
Bena
Deer River
Ball Club
Federal Dam
Squaw Point
Sugar Point
Onigum-Old Agency
Walker
L E E C H
L A K E
LAND USE:
Village Residential / Commercial
Village Mixed Use / Industry
Rural Residential
Conservancy
Restricted / Environmental Protection
Agricultural / Resource Utilization
SHORELAND ZONING
Natural Environment
Recreational Development
General Development
Leech Lake
Reservation
Business Committee
Box 308 Cass Lake MN 56633
BRW

Minnesota Pollution Control Agency

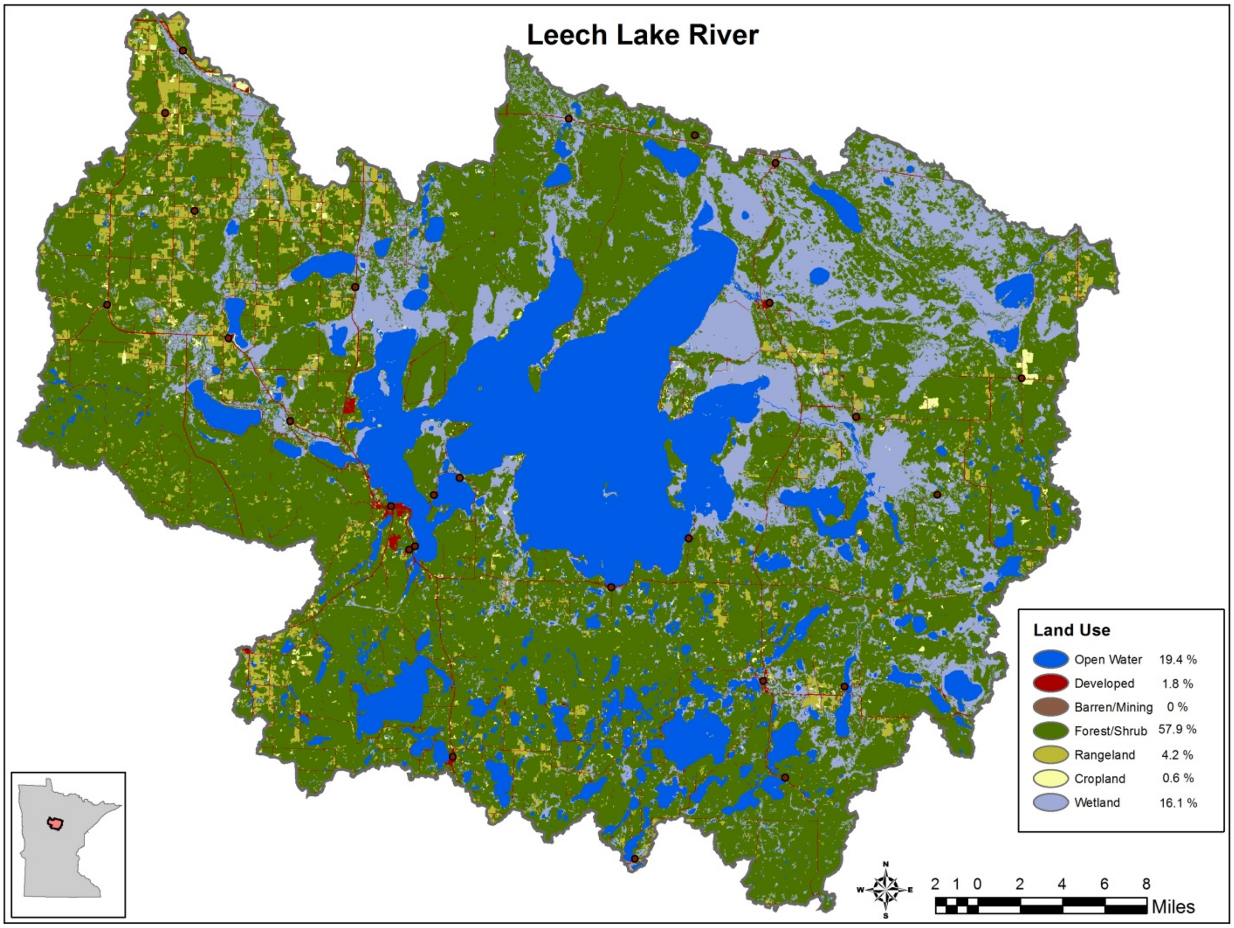


Level III Ecoregion
Driftless Area
Lake Agassiz Plain
North Central Hardwoods
Northern Glaciated Plains
Northern Lakes and Forests
Northern Minnesota Wetlands
Western Corn Belt Plains
Lakes
Streams
0 2 4 8 12 16
Miles
N
W
E
S

et al.

et al.

et al.


Leech Lake River
Land Use
Open Water 19.4 %
Developed 1.8 %
Barren/Mining 0 %
Forest/Shrub 57.9 %
Rangeland 4.2 %
Cropland 0.6 %
Wetland 16.1 %
2 1 0 2 4 6 8
Miles
N
S
E
W

John Persell

THE MINNESOTA CHIPPEWA TRIBE
RESEARCH LABORATORY
P.O. BOX 217
CASS LAKE, MN 56633

A WATER QUALITY ASSESSMENT OF THE LEECH LAKE WATERSHED

JULY 1997

RESEARCH AND REPORT PREPARATION
BY THE
LEECH LAKE DIVISION OF RESOURCE MANAGEMENT
AND THE
MINNESOTA CHIPPEWA TRIBE

STUDY AREA

GEOGRAPHY

Leech Lake is located in the northern lakes and forested ecoregion of Minnesota at approximately 47°, 10' north latitude and 94°, 30' west longitude. The 171 square miles (109,415 acres) of lake is a major reservoir in the Mississippi Headwaters drainage area. The 1,163 square miles (U.S. Corps, 1990) (744,320 acres) of watershed (Figure 1) are located in Leech Lake Indian Reservation, and Cass, Hubbard and Beltrami Counties. The majority of the lake and watershed reside in Election Districts 2 and 3 of Leech Lake Reservation.

The relief within the watershed ranges from rolling hills in the southern and western portions to nearly flat in the north and northwest. Elevations range from 1597 feet above mean sea level (MSL) to the lake surface elevation of approximately 1294 MSL. Land use types within the watershed are listed below in Table 1.

TABLE 1
LEECH LAKE WATERSHED LAND USE TYPES

LAND USE	PERCENTAGE OF TOTAL
FORESTED	51%
WATER	20%
WETLAND	20%
AGRICULTURAL	7%
TRANSPORTATION	2%
URBAN/RESIDENTIAL	1%

GEOLOGY

The topography of the Leech Lake watershed is a result of the advance of the Wadena and Rainey-Superior glacial lobes. These advancing glaciers formed the Itasca and St. Croix glacial moraines. The melt waters from these moraines carried sands and gravels which formed a sand cap over the eastern end of the Wadena drumlin field. In a later advance, the St. Louis sublobe of the Des Moines lobe entered the area creating the leaf hills moraine along the eastern Cass County line. After the retreat of this sublobe, a glacial lake formed north and east of the Federal Dam area leaving deposits of lacustrine associated silts, clays and fine sands.

is found in Walker Bay; the average depth is reported to be 13 feet (MNDNR). The estimated volume of the lake is 1,422,395 acre-feet (see Figure 2, Lake Bathymetry).

Leech Lake has five islands; Bear Island is the largest at approximately 1000 acres, followed in size by Minnesota, Pelican, Pipe and Goose. Numerous points and dropoffs combine with a variety of substrates, including sand, gravel, rock, silt and organic material, to support a diversity of aquatic habitats.

SOCIAL and ECONOMIC CHARACTERISTICS

Leech Lake is the focal point of a broad recreation based economy. An estimated 250,000 to 300,000 people visit the lake annually and spend $3.0 to $3.5 million for lake associated recreation (U.S. Corps, 1990). Corps information also shows 733 private lakeshore residences and 1384 lodging and camping units on Leech Lake. The permanent resident population in the watershed is estimated at 8,000 to 10,000. The multiple uses of the lake and watershed include use by the Leech Lake Band of Chippewa for commercial and subsistence hunting, fishing and gathering.

Several forest products industries, gaming casinos, and Tribal and County governments in the area of Leech lake are sources of employment outside the tourism economy.

HISTORICAL LAKE USES and MANAGEMENT

Shortly after the U.S. Civil War (1868) the U.S. Corps of Engineers recommended a survey to acertain "the practicability of forming large reservoirs on the headwaters of the Mississippi to aid in keeping navigation at low flow" (U.S. Corps, 1990). Six dams were proposed, and the first four authorized by Congress, Winnibigoshish, Leech, Pokegama and Pine River were constructed between 1881 and 1886. Sandy Lake and Gull Lake dams were completed in 1895 and 1912 respectively.

The water levels of Leech Lake are managed by the Federal Government for the following priorities: 1) downstream navigation, 2) Tribal Treaty hunting, fishing and gathering rights, and 3) recreation. The beneficial productivity for which the lake is currently managed includes a diverse fishery harvested primarily for walleye, whitefish, northern pike, muskie, white suckers, perch and panfish. Approximately 4,000 acres of wild rice beds on Leech Lake are also managed for harvest by Tribal members; a map showing the location of these wild rice beds is presented in Figure 3.

Historical water quality information is available from several sources: Robert Megard, University of Minnesota; John Persell, Minnesota Chippewa Tribe Water Research Lab; Minnesota DNR Fisheries; and John Persell/John Sumption in a collaboration between the Chippewa Tribe Lab and Cass County SCS. That information is presented in Appendix 1.

RESULTS

LAKE CHEMICAL, PHYSICAL

The information collected from Leech Lake during the study period is listed on the spreadsheets in Appendix 2. The Leech Lake station 1 (Walker Bay) was sampled on six different dates representing all four seasons. Leech Lake station 2 was sampled on five dates also representing all four seasons. The lake exhibited many of the same characteristics as were found in the 1990-91 lake assessment. All parameters analyzed show the lake to be a relatively clean ecosystem. The color of the lake averaged 6.2 units and the turbidity averaged 1.7 units. The average phosphorus concentration was 18 micrograms per liter (ug/l, parts per billion) and the average total Kjeldahl nitrogen was 588 ug/l. The nitrogen:phosphorus ratio was found to be 33, again indicative of a lake with healthy primary production. Mercury in the station 1water column was found to average 0.39 nanograms per liter (ng/l, parts per trillion), ranging from a low of 0.22 ng/l in the epilimnion (upper water column) to a high of 0.94 ng/l in the hypolimnion (lower water column). The mercury concentration at station 2 averaged 0.59 ng/l.

LAKE BIOLOGICAL

The total chlorophyll concentrations in Leech lake averaged 6.5 ug/l with chlorophyll (a) representing 2.6 ug/l, chlorophyll (b) 1.8 ug/l and chlorophyll (c) 2.1ug/l. Chrysophytes dominated the phytoplankton population for the 3 sample dates. The phytoplankton enumeration ranged from 1,272 colonies per milliliter (col/ml) on the October 25 sample date to 147 col/ml on the February 9 sample date. The two benthic invertebrate samples from the lake revealed species typical to clean productive ecosysyems; the species are detailed in Appendix 2.

Fifty fish were analyzed for mercury and PCBs and this data is presented in Appendix 2. Two fish were found to contain PCBs above 0.20 micrograms per gram (ug/g), and these were a 6.3 pound walleye at 0.38 ug/g and a 12 pound northern at 0.21 ug/g. These PCB levels appear relatively unchanged from previous years (Appendix 1 Historical Fish Data). The mercury concentrations in walleyes are approximately the same as the historical data base, ranging from 0.047 to 0.399 ug/g. The mercury concentrations in northern pike averaged 0.19 ug/g which was also comparable to the historical concentrations for similar size fish. The one notable difference in the 1995 northern data versus the historical is the highest concentration measured: 0.45 in 1990 and 0.74 in 1995 for comparable size fish. A consumption advisory will be developed based on the mercury and PCB data collected in this study.

STREAM PHYSICAL, CHEMICAL, BIOLOGY (Inflow)

The general characteristics of the 7 major streams entering Leech Lake are similar in the stream reaches near the lake. Sucker River, Portage Creek, Boy River, Whipholt Creek, Shingobee River, Kabekona River and Steamboat River, share many physical and chemical characteristics including mixed substrates of sand, gravel, rocks and occasional clay. Many streams have deposited organic material in the bottom of the channel overlying heavier substrates

TABLE 5

LEECH LAKE MERCURY LOADING DATA

LAKE AREA (LA): 109,415 ACRES (442.8 X 10^6 M^2)

LAKE ELEVATION: 1294 MSL

LAKE AVERAGE DEPTH: 13 FEET (3.94 M)

LAKE VOLUME (LV): 1,422,395 ACRE-FEET (1754.5 X 10^6 M^3)

ANNUAL INPUTS	
PRECIPITATION	6.7 POUNDS
TRIBUTARIES	0.97 POUNDS
TOTAL INPUT	**7.67 POUNDS**
ANNUAL OUTPUT	
DRAINAGE	**1.25 POUNDS**
ANNUAL MERCURY STORAGE (AMS) = (INPUT-OUTPUT)	6.42 POUNDS
LAKE MERCURY MASS (LMM) = (LAKE[Hg] X LV)	1.89 POUNDS
MERCURY LOADING RATIO (AMS/LMM) X 100	**340%**

DISCUSSION

Based upon the data collected during this study, it appears that erosion and nutrient abatement practices in the Leech Lake watershed are effective management tools. Continued efforts to implement these resource conservation practices may reduce the direct watershed phosphorus load by 10% to 15%, a substantial quantity for this relatively clean ecosystem. It is logical that a reduction in direct mercury loading from the watershed will result from these watershed conservation practices as well, however a quantification of this reduction would be premature due to the paucity of data for watershed mercury loading.

The major concern at this time is the atmospheric loading of phosphorus and mercury. These two loading factors emanate from similar sources, fossil fuel combustion being the primary source and soil erosion by the wind a secondary source. As degrading as this atmospheric deposition of phosphorus may be, the most severe problem is mercury deposition and the resultant fish contamination. As was stated above, 87% of the incoming mercury to Leech Lake is from direct atmospheric deposition. More stringent emission controls on coal power plants and waste incinerators will result in decreased mercury loads to Leech Lake from the atmosphere. A 1996 Mercury Study Report to Congress (USEPA) notes that " while selected studies provide some evidence of declining mercury concentrations on a very localized level, there does not appear to be a decrease in the global mercury burden. Appendix 5 lists the sources of mercury emissions for the United States as presented in the mercury report to Congress.

Decreased mercury loading to the lake will also be reflected in decreased mercury contamination in the fish over time. More research needs to be done to understand the time lag between decreased loading and decreased fish contamination, but we do know that continued high mercury loading levels transpose to continued high mercury in fish. The above mentioned mercury report to Congress acknowledges the increased potential for human health problems for those consuming fish higher in the aquatic food web (such as walleye, northern) and recommends that persons consuming fish follow consumption guidelines which have been generated for local lakes. Women of child bearing age (mercury can cross the placenta) and children are most at risk from mercury toxicity.

HYDROGEOLOGY AND WATER QUALITY OF GLACIAL-DRIFT AQUIFERS IN THE BEMIDJI-BAGLEY AREA, BELTRAMI, CLEARWATER, CASS, AND HUBBARD COUNTIES, MINNESOTA

By J. R. Stark, J. P. Busch, and M. H. Deters

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4136

Prepared in cooperation with the

MINNESOTA DEPARTMENT OF NATURAL RESOURCES and the BEMIDJI-BAGLEY GROUND-WATER STUDY STEERING COMMITTEE

St. Paul, Minnesota
1991

Statistical comparisons of common chemical constituents in water from wells completed in the unconfined-drift aquifer in several land-use areas suggest that concentrations of many constituents and physical properties are generally greater for wells in areas of commercial and residential land-use than for wells in areas of agriculture or forest land-use. These constituents include ammonia plus organic nitrogen, phosphorus, calcium, sodium, potassium, chloride, sulfate, silica, dissolved solids, and specific conductances. The mean values of ammonia nitrogen, magnesium, and fluoride are generally greater for wells in commercial land-use type areas than for wells in forested and agricultural land-use type areas. The mean concentration of nitrogen (NO_2 + NO_3, dissolved) is generally greater for wells in residential land-use type areas than for wells in forested and agricultural land-use type areas.

The Kruskil-Wallis test, a nonparametric statistical technique, indicated that for 12 of the 21 constituents sampled in common in all land-use type groups in the unconfined-drift aquifer, a relation between the concentration of these constituents and land use was found to be statistically significant.

INTRODUCTION

State and local governmental agencies in Minnesota are concerned about regional degradation of ground-water quality that might be caused by certain land uses and land-use practices. Of particular concern are pervasive land-use practices considered to be non-point sources of pollution. The use of chemicals in agriculture and in forestry, dense residential development with septic systems, urbanization, transportation, and waste disposal are practices and land uses that have potential for contaminating aquifers on a regional basis over a long period of time.

Recent studies in surficial, sand-plain aquifers in agricultural counties in Minnesota have indicated that specific conductance, chloride, and nitrate concentrations have increased significantly in the last decade. Nitrate levels in many shallow wells currently exceed recommended limits for domestic and livestock consumption established by the Minnesota Pollution Control Agency (1988). These studies also indicate that nitrate has gone undetected in previous studies because wells selected for sampling were screened too deeply in the aquifer. Also, low concentrations of pesticides have been detected in shallow ground water.

Increasing population, intensified agricultural and commercial activity, and localized ground-water contamination from waste-disposal sites within the 550-square-mile Bemidji-Bagley unconfined-drift aquifer have resulted in concerns about present and future ground-water quality in the Bemidji-Bagley area in north-central Minnesota (fig. 1). State and local officials identified the need for a program to establish background water quality in aquifers, to determine seasonal variations, to determine impacts of various land uses on water quality, and to provide a means to observe future trends in water quality.

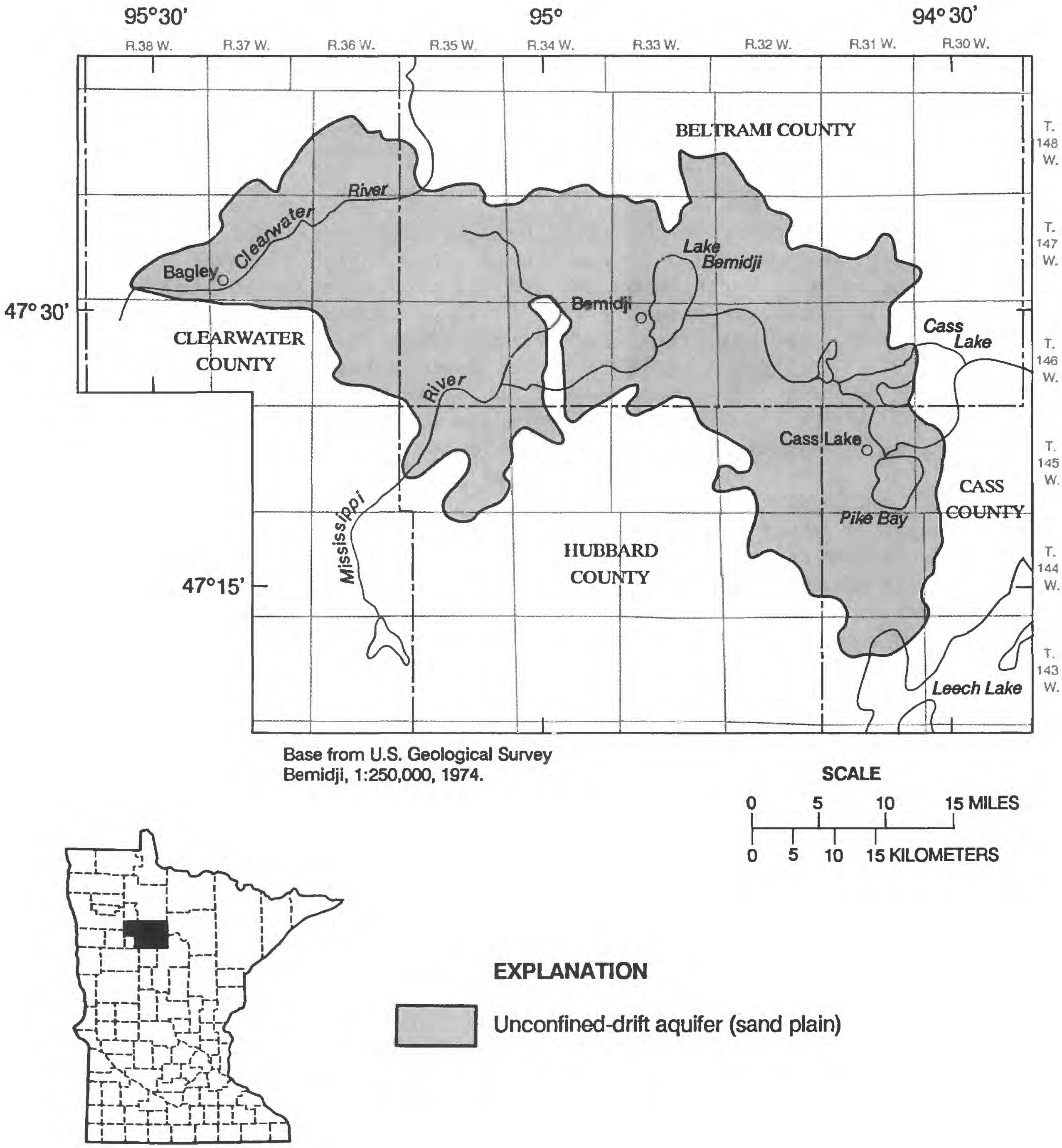


Figure 1.--Location of Bemidji-Bagley study area

Prior to this study, data in the Bemidji-Bagley area were not adequate to characterize ground-water quality at a scale comparable to that of the land uses that might affect water quality. Existing water-quality data generally were not adequate to assess long-term changes because too few wells were sampled or the samples were not analyzed for the appropriate constituents. Furthermore, previous sampling has been too infrequent to determine seasonal changes in water quality.

Agricultural interests in the Bemidji-Bagley area were considering increased use of ground water for irrigation of crops to (1) increase yields, (2) assure productivity during drought, and (3) produce crops on land that could not be cultivated economically with dry-land farming practices. Little was known about the geology, areal extent, thickness, hydraulic properties, or potential yields of drift aquifers in the Bemidji-Bagley area. There were concerns about the effects of increased withdrawals from aquifers because of uncertainty about (1) long-term yields of wells open to these aquifers, (2) effects of pumping and drought on water levels and streamflow, and (3) possible interference between nearby wells pumping from the same aquifer. The hydrogeologic framework of drift aquifers in the Bemidji-Bagley area and movement of ground water also needed to be defined before water-quality data could be adequately interpreted. The U.S. Geological Survey, in cooperation with the Minnesota Department of Natural Resources (MDNR) and the Soil and Water Conservation Districts of Beltrami, Cass, Clearwater, and Hubbard Counties conducted a 3-year study (1985-88) to appraise the ground-water resources in the area. This report presents the findings of that study.

Purpose and Scope

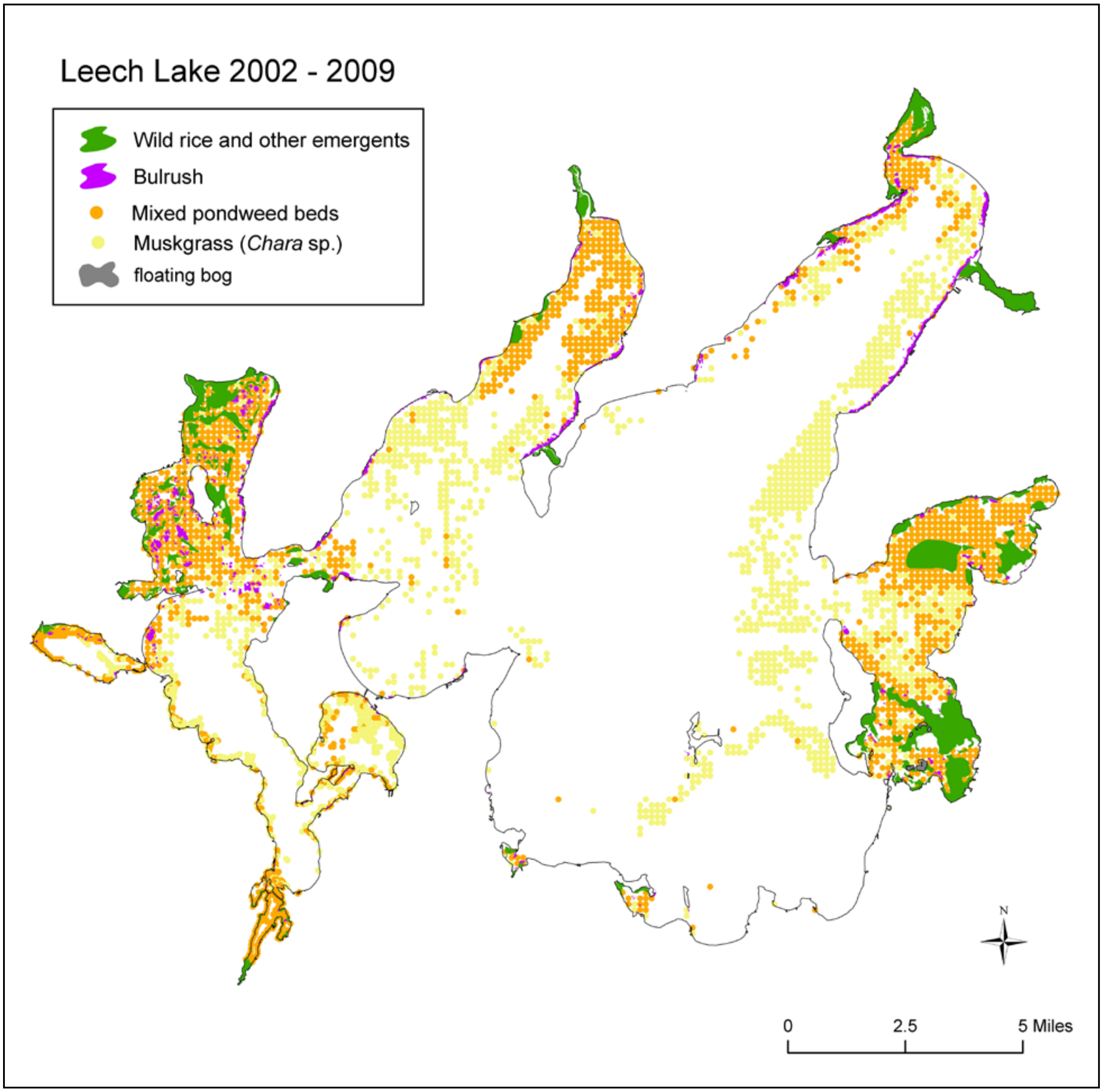
This report describes the occurrence, availability, and quality of ground-water in the Bemidji and Bagley area of north-central Minnesota. The report objectives are to (1) describe the hydrogeologic properties, water movement, and potential yield of the unconfined-drift and uppermost confined-drift aquifers, (2) define the quality of ground water in relation to hydrogeologic conditions and land use, (3) describe seasonal changes in water quality, and (4) provide baseline hydrologic and water-quality data for use in future assessments of long-term trends.

The unconfined-drift and uppermost confined-drift aquifers are the only aquifers considered in detail in this report. Other aquifers undoubtedly exist below these aquifers but data are insufficient to define their nature or extent.

This study was conducted in two phases. The first phase was to define ground-water resources of the unconfined-drift and uppermost confined-drift aquifers in the Bemidji-Bagley area. The second phase consisted of defining ground-water quality in these aquifers.

Aquatic Vegetation of Leech Lake

CASS COUNTY, MINNESOTA, 2002 - 2009



Leech Lake, but these are not on the bays containing the duck food. Leech Lake is a good fishing lake, pike, pickeral, bass and some white fish being found. The outlet of Leech Lake, Leech Lake River, is partially closed by a Government dam. At present the water level of the lake is about 6 feet lower than its level about eight years ago. There is some agitation around Walker to have the level raised at least a foot to aid navigation, especially in the narrows."

"Outside of the bays east of Bear Island, Steamboat Bay and Kabekona Bay just south of Steamboat, Sucker Bay and the large bay just east of Sucker Bay, there is little aquatic vegetation. "

- Shunk and Manning, 1924

Otter Tail Point, Leech Lake ca. 1925

Source: Historical Society of Minnesota.

Windswept shore of Leech Lake ca. 1940

Source: Historical Society of Minnesota.

The 1924 surveyors describe Leech Lake vegetation:

"Rooted aquatic plants are common only in sheltered bays or on shorelines protected from westerly winds." - Schupp, 1978.

Schupp (1978) provides a similar summary:

POTENTIAL THREATS TO NATIVE PLANTS

There are multiple factors that may directly or indirectly reduce the quality or quantity of aquatic plant communities in Leech Lake.[3]

Shoreland development

Shoreland development changes lake ecosystems and effects fish and wildlife habitat, water quality, and biota of lake ecosystems (Engel and Pederson 1998, Ramstack et al. 2004). Aquatic plants may

[3] For detailed information on threats to wild rice (Zizania), see MnDNR Wild Rice Study, 2008.

be indirectly affected by increased nutrient and sediment loading and decreased water clarity. Studies that compared developed and undeveloped lake sites found less plants and lower diversity at developed sites (Elias and Meyer 2003, Byran and Scarnecchia 1992, Jennings et al. 2003). Decreases in water clarity can also restrict aquatic plants to only shallow depths where they can obtain sufficient sunlight.

Shoreland development can also directly impact aquatic plants if developers and landowners destroy vegetation to create beach areas adjacent to the shore. Emergent plants, such as bulrush, are particularly susceptible to this type of activity because they often do not regenerate after initial cutting. Radomski (2006) determined that floating-leaf and emergent vegetative cover in central Minnesota lakes was negatively affected by development for the period from 1939 to 2003.

Motorboat activity

Motorboats can harm aquatic habitat by cutting and/or uprooting plants (Asplund 2000) and by increasing turbidity (Yousef et al 1980) and increasing wave action (Vermaat and de Bruyne 1993). At sites that are repeatedly disturbed (ex. boat channels), changes to sediment type may further prevent or slow recolonization (Zieman 1976). Both emergent plants, like wild rice (Tynan 2000), and submerged plants (Asplund 2000) can be harmed by motorboats.

Water level changes

Naturally occurring water level fluctuations are important for the plant communities of Leech Lake. Artificially high and stable water levels may result in increased erosion, loss of fish spawning and foraging habitat, loss of wild rice beds, loss of aquatic vegetation, loss of open beach habitat, and the loss of wildlife due to winter drawdown (ACOE 2009). Water level increases can uproot wild rice plants and the floating-leaf stage of wild rice is particularly sensitive to water level changes.

Invasive species

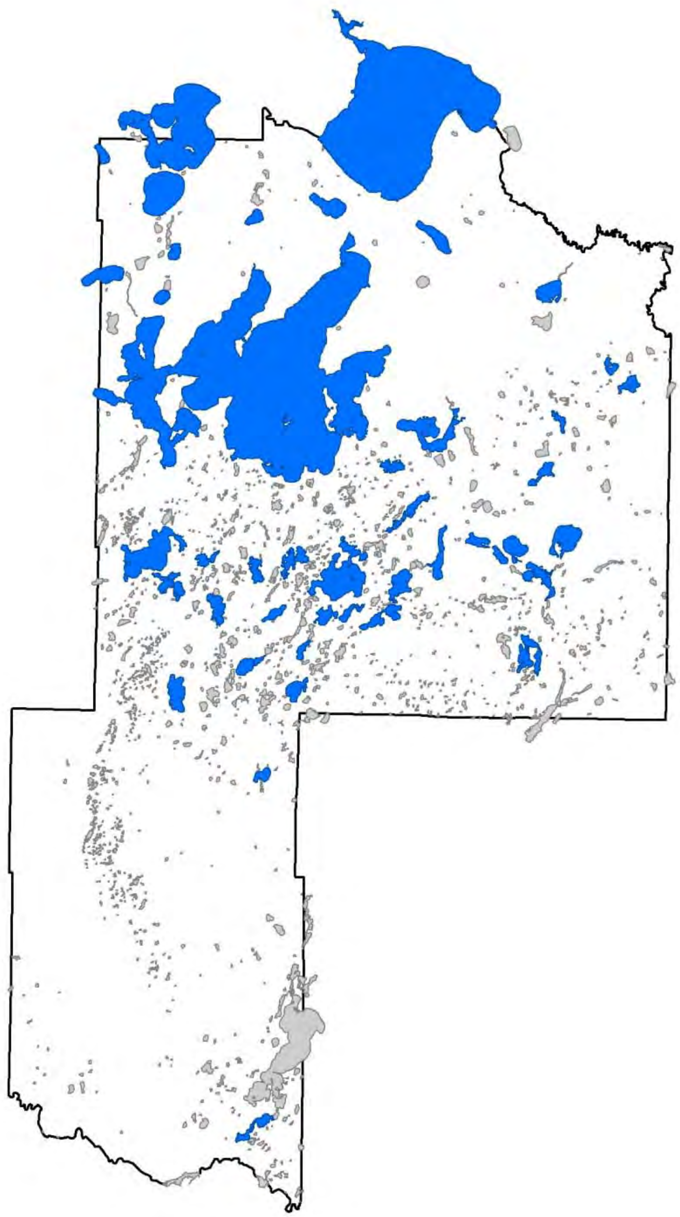
Several new non-native species have recently become established in Leech Lake but it is difficult to predict how they may interact with native plants. Certain management activities to control invasive plants also have the potential to impact native plants, particularly if native plants occur within control areas.

Non-native aquatic animals

Non-native aquatic animals that have become established in Leech Lake include rusty crayfish and banded mystery snails. These species may have direct and indirect impacts on aquatic vegetation.

Rusty crayfish (*Orconectes rusticus*) were first documented in Leech Lake in 1990 (Helgen 1990) but their distribution and abundance within the lake has not been quantitatively assessed. Crayfish, in general, and rusty crayfish in particular, can directly impact aquatic macrophytes by cutting and eating plants (Lodge and Lorman 1987). Crayfish also clip or uproot macrophytes as they burrow or feed on epiphytic snails. Crayfish activity may have both negative and positive impacts to the plant community (Pintor and Soluk 2006). Large numbers of crayfish may not lead to high plant consumption because, for example, the presence of snails may provide a supplemental food source (Olson, et al. 1991). Maezo (2010) also suggests that in some lakes, specifically large lakes with

Cass County Large Lakes Assessment



2012

Cass County Environmental Services
Minnesota Board of Soil and Water Resources

Table 8. Cass County Lakes with declining water quality trends.

Lake	Parameter	Date Range	Trend	Probability
Ponto	Transparency	1998-2011	Declining	95%
Stony	Transparency	1997-2011	Declining	99%
Inguadona (North Bay)	Transparency	1989-2010	Declining	90%

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology (Figure 3). The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. The MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion. For the purpose of this graphical representation, the means of the reference lake data sets were used.

Figure 3. Minnesota ecoregions.

All of Cass County is in the Northern Lakes and Forests (NLF) Ecoregion. This heavily forested ecoregion is made up of steep, rolling hills interspersed with pockets of wetlands, bogs, lakes and ponds. Lakes are typically deep and clear, with good gamefish populations. These lakes are very sensitive to damage from atmospheric deposition of pollutants (mercury), storm water runoff from logging operations, urban and shoreland development, mining, inadequate wastewater treatment, and failing septic systems. Agriculture is somewhat limited by the hilly terrain and lack of nutrients in the soil, though there are some beef and dairy cattle farms.

Most of the lakes evaluated in this report fall within the expected ecoregion ranges. Boy, Lower Sucker and Vermillion Lakes are slightly poorer than the expected ecoregion ranges. Big Deep, Long, Ponto, Stony, Sylvan and Ten Mile lakes are better than the expected ecoregion averages.

Statewide Assessments

Lake monitoring should be designed and accomplished for achieving specific goals. There are two main purposes for lake monitoring in Minnesota. The first is the MPCA statewide 303(d) and 305(b) assessments that occur every two years. Statewide MPCA Assessments are performed with a minimum data set of 10 data points each of total phosphorus, chlorophyll *a*, and secchi depth over a two-year period in the past 10 years. This assessment can be considered the first step to understanding a lake.

The second purpose for lake monitoring is ongoing education, awareness and lake condition. After the lake's current condition is determined, associations can monitor water quality each year to learn about seasonal variability, year to year variability, and if the water quality is improving, declining or staying the same (trend analysis). Condition monitoring involves collecting at least 5 samples during the growing season (the typical program involves monitoring once a month May-September) each year.

Chippewa National Forest

2011 Annual Report

Payments to Counties

CHIPPEWA	PILT	Title I	SRS Title II	TOTAL
Cass	451,440	345,026	60,887	857,353
Itasca	444,435	450,396	79,481	974,312
Beltrami	86,924	95,930	16,928	199,782
TOTAL	982,799	891,352	157,296	2,031,447

SUPERIOR	PILT	Title I & III	SRS Title II	Thye-Blatnik	TOTAL
Cook	210,814	554,052	48,178	2,025,000	2,838,044
Koochiching	9,673	81	-0-	N/A	9,754
Lake	239,697	548,157	47,665	2,512,500	3,348,019
St. Louis	279,324	632,095	54,964	1,612,500	2,578,883
TOTAL	739,508	1,734,385	150,807	6,150,000	8,774,700

2011 Accomplishments

TIMBER

Harvested (Million Board Feet) 34,803

Reforestation (Acres) 1930.5

Timber Stand Improvement 1647.4

Fuelwood Permits ($20) 219

Christmas Tree Permits 166

Bough Permits 49

HUMAN RESOURCES

Senior Employment 20

Volunteers 255

Youth Conservation Corps 6

Full Time Employees 127

Summer Visitor Centers 15,000 visitors

Conservation Ed Programs 320

FIRE AND FUELS

Prescribed Burns (# Fires/Acres) 10 / 3,389

Wildfires (# Fires/Acres) 11/13

Hazardous Fuels Reduced (Acres) 1,227

Hazardous Fuels (non WFHF Acres) 5,869

WILDLIFE

Terrestrial Habitat Restored (Acres) 7089

Inland Streams Enhanced (Miles) 26

Inland Lakes Enhanced (Acres) 200

Soil Water Resource Improved (Acres) 152

LANDS

Right-Of-Way Cases 2

Special Use Permits (Total) 690

Land Acquisition (Acres) 0

Mineral Permits (Issued) 17

Total Nat'l Forest Acres 666,627

Boundary Management (Miles) 15

Total Acreage within Boundary 1,599,611

ROADS AND TRAILS

Road Maintenance (miles) 479.9

Road Improvement (miles) 53.9

Road Decommissioned (miles) 16.9

Trails Maintained to Standard (miles) 192

CHIPPEWA NATIONAL FOREST

REINVESTING IN AMERICA

ANNUAL REPORT 2010

PAYMENTS TO COUNTIES

On October 3, 2008, the Secure Rural Schools and Community Self-Determination Act of 2000 was reauthorized as part of Public Law 110-343. The new Secure Rural Schools Act has some significant changes. To implement the new law, the Forest Service requested states and counties to elect either to receive a share of the 25-percent rolling average payment or to receive a share of the Secure Rural Schools State (formula) payment. A county electing to receive a share of the State payment that is greater than $100,000 annually was required to allocate 15 to 20-percent of its share for one or more of the following purposes: projects under Title II of the Act; projects under Title III; or return the funds to the Treasury of the United States.

On January 15, 2009 the Forest Service began distributing more than $477 million to 41 states and Puerto Rico for improvements to public schools, roads and stewardship projects. These payments include 25% payments, special acts payments and Secure Rural Schools Act State payments. Under the Secure Rural Schools Act an additional $52 million was made available to be used for projects recommended by local resource advisory committees to maintain infrastructure, improve the health of watersheds and ecosystems, protect communities, and strengthen local economies.

Seven counties in Minnesota received a total of $12,745,834 from the Forest Service in 2010. Thye-Blatnik numbers apply to Superior National Forest wilderness only. On the Chippewa National Forest, a total of approximately $800,000 was brought to the Resource Advisory Committee.

SUPERIOR	PILT	SRS	SRS Title II Funds	Thye-Blatnik	TOTAL
Cook	$210,829	$690,080	$55,206	$2,025,000	$2,981,115
Koochiching	$9,781	$89	$0	$0	$9,870
Lake	$239,788	$649,978	$552,480	$2,512,500	$3,954,746
St. Louis	$1,073,923	$748,831	$59,906	$1,612,500	$3,495,160
CHIPPEWA	**PILT**	**SRS**	**SRS Title II Funds**		**TOTAL**
Cass	$428,262	$467,712	$70,156		$966,130
Itasca	$411,719	$603,660	$90,549		$1,105,928
Beltrami	$78,581	$134,178	$20,126		$232,885
Total					**$12,745,834**

2010 ACCOMPLISHMENTS

TIMBER

- Harvested (Million Board Feet) ... 35,727
- Reforestation ... 2,222
- Timber Stand Improvement ... 1,177
- Fuelwood Permits ($20) ... 79
- Christmas Tree Permits ... 176
- Bough Permits ... 42

HUMAN RESOURCES

- Senior Employment ... 23
- Volunteers ... 166
- Youth Conservation Corps/MCC ... 7/10
- Full Time Employees ... 108
- Summer Visitor Centers ... 10,839
- Conservation Ed Programs ... 284

FIRE AND FUELS

- Prescribed Burns (#Fires/Acres) ... 9 / 1,135
- Wildfires (#Fires/Acres) ... 49 / 232
- Hazardous Fuels Reduced (Acres) ... 1,928
- Hazardous Fuels (non-WFHF Acres) ... 5,158

WILDLIFE

- Terrestrial Habitat Restored/Enhanced (Acres) ... 5017
- Inland Streams Enhanced/Restored (Miles) ... 20
- Inland Lakes Enhanced/Restored (Acres) ... 100
- Soil Water Resource Improved (Acres) ... 704

LANDS

- Right-Of-Way Cases ... 1
- Special Use Permits (Total) ... 665
- Land Acquisition (Acres) ... 2.5
- Mineral Permits (Issued) ... 16
- Total Nat'l Forest Acres ... 666,536
- Boundary Management (Miles) ... 16
- Total Acreage within Boundary ... 1,599,611

ROADS AND TRAILS

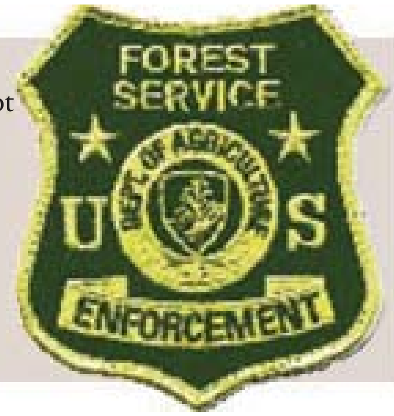
- Road Maintenance (Miles) ... 616.05
- Road Improved (Miles) ... 86.4
- Road Decommissioned (Miles) ... 15
- Trails Maintained to Standard (Miles) ... 192
- Roads Open to OHV (Seasonal Miles) ... 1,345

CHIPPEWA NATIONAL FOREST

ANNUAL REPORT 2003

Know Your National Forest Regulations!

Forest law enforcement officers work hard to cover the 666,523 acres of Chippewa National Forest land. Working cooperatively with State Conservation Officers, Leech Lake Tribal Officers and the County Sheriff's office, federal officers work with everything from natural resource violations, illegal drug operations, and visitor safety. Test your knowledge of National Forest System regulations.



True or False:

1) Portable hunting stands may remain in place through the hunting season, and do not have to be removed after each evening's hunt.
2) Commercial bear baiters on National forest Lands must apply for a permit.
3) ATV use on the Chippewa National Forest is unrestricted.
4) In 2003, Forest law enforcement officers found evidence of meth labs and meth lab dumping.
5) Timber theft refers to campers taking an oversupply of firewood from developed recreational areas.

Answers:

1) Only portable stands that do not damage trees and are removed at the end of the hunt are permitted. Officers discovered over 500 illegal permanent stands on the Forest and documented hundreds of violations for resource damage connected with permanent deer stands. Hunters do not need to remove their portable stands each night. They may set up their stand one week prior to the season start, and keep in place until one week after the hunting season. *True*

2) Any commercial operation on National Forest lands requires a permit, including bear baiting/guiding. Anyone working with a commercial operation on National Forest land needs to visit with the Lands Specialist. In 2003, 8 permits were issued for over 400 bear baiting stations. Over 300 incident reports, 15 violation notices and 8 warnings were written, including bear hunter resource violations and non-compliance with the bear guiding permit. *True*

3) Along with State-wide regulations regarding Recreational Motor Vehicle (RMV) use during the hunting season, Federal regulations are also enforced. On the Chippewa National Forest, RMV crosscountry travel off roads and trails is prohibited throughout the year. RMVs may operate on forest roads or trails unless posted closed, gated or bermed to restrict motorized use. In the winter, snowmobilers can travel over 600 miles of trail and unplowed roads on the Chippewa. *False*

4) Meth labs are increasing across the state, and the Chippewa National Forest is no exception. Forest Service officers work with the Paul Bunyan Drug Task Force and Arrowhead Drug Task Force to close down meth labs and marijuana gardens found on the Forest. Law enforcement strives to keep visitors safe by identifying these dangerous sites and ask the visitors report any unusual activity. *True*

5) Timber theft is more directly associated with land trespass. Increasing land sales around National Forest system lands are bringing timber trespass cases up as well. Almost 90% of timber trespass on the Chippewa National Forest comes from private landowners cutting across Forest boundaries. If you are a private landowner, make sure you know the boundaries of your property and public lands. Landowners who cut timber on national forest land are ticketed and charged at the fair market value for the trees cut. *False*

On a side note — campers are allowed to collect dead and down wood for campfires without a permit, though cut and dried firewood is available for purchase at the campground host site for $5.00/bundle. Free-use permits are required for those wishing to collect firewood for personal home heating use. Up to 4 cords of dead and down wood (only) may be collected each year with this free permit.

Want to learn more? Contact the Forest Service Law Enforcement officer thru the Forest Supervisor's Office or check the USDA Forest Service web page. Information on Federal regulations may be found at ***www.fs.fed.us/lei , Forest Rules.***

APPENDIX A. SUMMARY OF THE ANALYSIS OF THE MANAGEMENT SITUATION – CHIPPEWA AND SUPERIOR NATIONAL FORESTS

The regulations to implement the National Forest Management Act require, as part of the planning process, an analysis of the management situation (AMS). The purpose of the AMS is to identify the need for change (if any) from the direction in the current Forest Plan. The AMS is also the determination of the ability of the planning area to supply goods and services in response to society's demands. Detailed Analysis of the Management Situation papers were prepared for the following topics: Fire Management, Fish Habitat Management, Old Growth, Rare Natural Resources, Recreation, Riparian Management, Timber Management, and Wildlife for both the Chippewa and Superior National Forests. These documents are detailed and contain much additional information compared to those included in the following summaries. The complete AMS and other resource assessment documents are included in the official planning record.

This section of the appendix provides a summary of the AMS for each of the above topics. The AMS was developed for both the Chippewa and Superior National Forests in the joint Forest Plan revision process. The intent of the summary is to give an overview of each resource what anticipated demands for the resource, and a discussion of the change needed in a revised plan. The format of the AMS summary is generally as follows:

1. Introduction
2. Projection of Demand – Assessment of the Demand from the Forest, and Assessment of ability to produce Goods and Services
3. The Need for Change – Problems with the Existing Direction, Assessment of the Need and Opportunity to Change Management Direction

Additional information not contained in the summary (but contained in the planning record) includes:

- National Direction
- Direction from the 1986 Forest Plans
    - Goals, standards, and guidelines
    - Projected outputs and activities
    - Future activities projected under current management
    - Expected future conditions if current management were to continue.

Need for Change

Known Problems with the Existing Direction or Situation

The Chippewa and Superior National Forest Plans lack goals and objectives for managing fish habitat. Goals and objectives are needed in order to fulfill the earlier described national directives and as a basis for prescribing habitat manipulation (improvement). While fish habitat improvement projects under current Plans have improved fish habitats at specific locations, a long-term vision and strategies for fish habitat improvement are warranted for both National Forests.

The setting of goals and objectives for fish habitat should be founded in our understanding of the natural capabilities and limitations of aquatic ecosystems. Aquatic habitat inventory data and associated classification of aquatic systems on the two Forests is inadequate to fully characterize these capabilities. However, where available, limited knowledge of historical conditions (such as whether or not streams ever supported native trout) or influences (such as the impacts of turn-of-the-century log drives on streams) can be used to help set reasonable goals.

Goals for managing fish habitat are also needed as a basis for establishing a clear working relationship with our fish resource management partners (DNR and Tribal). Current Forest Plans do not adequately recognize Tribal involvement in cooperatively managing fish resources, including their authority to regulate Tribal member commercial and subsistence fishing harvest, or their role in fish population assessments, enforcement activities, and water quality monitoring.

Current Forest Plans do not provide adequate direction for integrating the protection and improvement of fish habitat with other resources. An assessment of fish resources in a whole watershed context is needed to meet the Forest Service Natural Resource Agenda. Because of the critical link between riparian area condition and the quality of fish habitat, problems with current riparian area direction (inconsistent definition and management direction) need to be addressed.

While current Forest Plan standards and guidelines, including State of Minnesota Best Management Practices, are important in protecting the quality of water in which fish reside, they do not provide enough direction for proactive management, or protection, of fish habitat. For example, while filter strips along lakes and streams limit the amount of mineral soil exposed along water bodies, they do not limit vegetation removal. Vegetation is crucial to providing in-stream and in-lake structure (or large woody debris), shade, decomposing leaf litter, and bank stability.

Monitoring of fish habitat, more specifically the selection of management indicators for fish/fish Management Indicator Species, needs to be re-examined on both Forests. Specific data regarding the status and abundance of Management Indicator Species are difficult to obtain, and doubt exists whether the indicator species selected in current Forest Plans ("commonly fished" species) are representative of all aquatic communities or are adequate indicators of effects of management activities on aquatic habitat. There is need to consider the utility of other indicators (especially invertebrate species) in addition to, or in lieu of, existing Management Indicator Species. Tracking of aquatic community status may be needed in revised Plans to effectively monitor whether aquatic resources goals are being achieved.

As mentioned above, Forest Plans of the two Minnesota National Forests are not consistent in their management goals pertaining to fish and wildlife population viability. There is no logical reason for the differences.

Current Plans fail to clearly state that Threatened or Endangered fish species have not been found on either Forest, or that R9 Sensitive species such as Pugnose Shiner (at four known locations on Chippewa National Forest; unknown on Superior National Forest) and Lake Sturgeon (possibly on Superior National Forest) have been found. Current Plans also fail to address other aquatic communities or species of concern, such as native lake trout populations on the Superior.

There is need to re-think the current management guideline which excludes habitat management for beaver along all State Designated Trout Streams within the Superior National Forest. Recognizing that many "designated" reaches do not in fact support trout, there may be opportunities to refine this guideline, where actual supporting site level steam data is available, to allow management on some reaches for beaver or other resources that have in the past been viewed as incompatible with trout.

Current Forest Plans do not identify, or direct how to manage in response to, exotic aquatic species (i.e. purple loosestrife & rusty crayfish - here now; and Eurasian Water Milfoil & Zebra Mussel - potential threats).

Current Forest Plans do not identify or take into account effects of Forest Service or non-Forest Service shoreline development or in-lake (or in-stream) recreational uses on fish habitat. Considering these effects may result in changes in guidelines on National Forest land for three related resource areas:

- Land Adjustment - Better understanding of these effects may lead to direction designed to maintain or improve the National Forest role in providing undeveloped shoreline.
- Management of shoreline special uses - Improved direction may be needed on monitoring and administering FS shoreline special use permit sites to address threats to fish habitat such as leaky fuel tanks, inadequate septic systems, and inappropriate removal of shoreline vegetation.
- Providing lake and stream access - Improved understanding of aquatic system capabilities (e.g., fish productivity or sensitivity to changes in water quality) on individual lakes and streams contributes to re-evaluation of the types and distribution of Forest Service-provided water access across both National Forests.

Current Forest Plans do not identify research questions that need to be addressed to more fully understand aquatic resources. Potential aquatic research topics may include: groundwater protection (i.e. springs, seeps) and its importance to aquatic resources and the effects of watershed condition on aquatic resources.

The current Chippewa Forest Plan allows for stabilization of eroding National Forest shoreline on artificially regulated lakes only in cases where National Forest or private developments are threatened by lakeshore or stream bank recession. This severely hampers protection of fish habitat, particularly on the large Mississippi Headwaters reservoirs (Cass, Winnibigosish and Leech Lakes) where shoreline erosion measured in units of miles continues to degrade fish habitat through sediment deposition. The current guideline needs to be changed to encourage, rather than restrict, shoreline stabilization wherever doing so will protect or enhance fish habitat.

Assessment of Need and Opportunity to Change Management Direction and the Ability to Resolve Issues and Concerns through the Planning Process

Forest Plan revision presents a prime opportunity to integrate goals and objectives to meet the demands placed on fish habitats with demands placed on other resources in the National Forests of Minnesota. Recently improved (though still very limited) understanding of natural capabilities of, and historical influences on, aquatic ecosystems can be used as a basis for developing goals and objectives that are ecologically sustainable and reasonably achievable.

- *Riparian management* - Riparian areas provide habitat components which are essential for fish production and protection (for example large woody debris, bank stability, leaf litter inputs and shade)
- *Road management* - Road construction and maintenance can have lasting impacts on fish habitat. Stream crossings have the potential to degrade fish habitat through increased sedimentation and blockage of fish passage to preferred habitats.
- *Biodiversity* - This is of concern to aquatic, as well as terrestrial, communities. Across the nation, the

Minnesota Pollution Control Agency

:

Tribal Rights and Interests

This section is a compilation of reports included in the annual Monitoring and Evaluation Report for FY 2005 and 2009. The annual reports provide details on commitments, activities and successes with the Leech Lake Band of Ojibwe. The intent is to have this information available in one document for ease of reference and use.

The monitoring questions and drivers are from the 2004 Forest Plan and are the same from year to year. They are presented at the beginning of this document. For each year, there is a background discussion, followed by a listing of monitoring activities and a brief evaluation and conclusion starting with FY 2005.

Monitoring Question:

The Forest Plan states three conditions to be monitored:

- Is Forest management helping to sustain American Indians' way of life, cultural integrity, social cohesion, and economic well being?
- Is the Forest facilitating the right of the Tribe to hunt, fish, and gather as retained via treaty?
- Are government to government relationships functional?

Monitoring Drivers:

D-TR-1 Lands within the Forest serve to help sustain American Indians' way of life, cultural integrity, social cohesion, and economic well-being.

D-TR-2 The Forest Service continues to work within the context of a respectful government-to-government relationship with Tribes, especially in areas of treaty interest, rights, traditional and cultural resources, and ecosystem integrity. The Forests provide opportunities for traditional American Indian land uses and resources.

D-TR-3 The Chippewa National Forest facilitates the exercise of the right to hunt, fish, and gather as retained by Ojibwe whose homelands were subject to treaty in 1855 (10 Stat. 1165). Ongoing opportunities for such use and constraints necessary for resource protection are reviewed and determined in consultation with the Leech Lake Band of Ojibwe.

O-TR-1 Improve relationships with American Indian tribes in order to understand and incorporate tribal cultural resources, values, needs, interests, and expectations in forest management and develop and maintain cooperative partnership projects where there are shared goals.

O-TR-2 Maintain a consistent and mutually acceptable approach to government-to-government consultation that provides for effective Tribal participation and facilitates the integration of tribal interests and concerns into the decision-making process.

O-TR-3 The Forest Service will work with the appropriate tribal governments to clarify questions regarding the use and protection of miscellaneous forest products with the objective of planning for and allowing the continued free personal use of these products by band members

~~project.~~	
~~In March 2007, CNF worked with LLBO and BIA to identify FS roads for inclusion in the Indian Reservation Roads inventory (IRR). The IRR program is the tribal equivalent of the Federal Highways program and has excellent potential for new cooperation, maintenance and improvement of FS roads.~~	~~Employment~~ ~~Partnership~~
The Forest Service, Minnesota Conservation Corps, Lady Slipper Scenic Byway Association, and the Red Lake Band of Chippewa Indians are cooperating to initiate a pilot conservation-based language immersion camp located at Rabideau CCC National Historic Landmark on the Blackduck Ranger District in the summer of 2008. The Red Lake Tribal Council has as one of its highest priorities the well-being, health and future of its children and families. The Red Lake Department of Family and Children's services has been mandated to develop and implement programs and services for the safety, well-being and positive development of Red Lake children and families. Young people will have a place to go to simultaneously gain work experience, earn an educational stipend, learn about the natural environment of which they are a part, or reconnect with cultural and family activities.	Environmental & Cultural Awareness Training Employment
In fall of 2007, the CNF hosted Susan Johnson– R2 Tribal Relations Program Manager. Susan's visit was to help the CNF and LLBO better understand the Tribal Forest Protection Act, and Stewardship Contracting as one tool for establishing long term economic/employment opportunities for the Band. The meeting helped the Forest and LLBO to better understand the capacity of the Band to launch into a forest based economic venture under authorities of the Tribal Forest Protection Act. There was consensus more discussion needs to occur as to what Forest projects would serve the B~~b~~and's interests. It was also evident that the questions about tribal capacity would need further exploration before the Band can develop a solid proposal.	Economic Development and Partnerships
~~A Tribal Liaison position developed in cooperation with the LLBO was filled. Neil Peterson, a CNF employee will spend 40% of his time in that position. The liaison position is designed to focus on outreach and recruitment for employment, mutual cultural awareness, initiating development of a Memorandum of Understanding, and partnership building with LLBO.~~	~~Cultural Awareness~~ ~~Partnership~~
Implementation began in October 2007 of a Forest-Tribal agreement to cooperatively clean up illegal dump sites in key riparian areas on the CNF using the skills of the Leech Lake Public Works Department and CNF Soil/Water expertise. In August 07 this partnership was highlighted in a presentation by the Tribal Liaison at the Minnesota Tribal Conference.	Restoration Partnership
The CNF co-sponsored a Tribal Relations Training with the Huron Manistee National Forest. Attendees included the Forest Supervisor and Deer River District Ranger.	Cultural Awareness
Training and information on Treaty Rights and Trust Responsibilities was conducted for the Forest Leadership Team in December 2007.	Cultural Awareness
~~A Traditional Cultural Resources and Properties workshop was held in February 2007 to help interdisciplinary teams use a database of traditional resource information. A protocol was developed and implemented that facilitate communication with Local Indian Councils, and 106 consultation.~~	~~Cultural Awareness~~

5C

Phone: 218-328-6225
Fax: 218-328-6226
Website: www.cohasset-mn.com

CITY OF COHASSET

305 N.W. First Avenue • Cohasset, Minnesota 55721

The City of Cohasset is pleased to announce the Itasca Energy Center ("IEC") project. IEC is a \$300-million capital investment project to build a natural gas energy facility utilizing 30 acres in the Cohasset Phase II Industrial Park. The project will be a state of the art 400 megawatt power facility. Construction is scheduled to begin in 2018 after the permitting process is complete.

The Itasca Energy Center ("IEC") will bring enormous benefits not only to the City of Cohasset, but to Itasca County and the State of Minnesota as well. Declining use of coal-fired generation and the loss of associated jobs negatively impacts our local and state economy. The IEC will create more than 350 new union jobs during construction, and will provide permanent employment for more than 20 union workers currently facing the prospect of losing their jobs with the closure of coal fired generation in the region. The IEC will have a ripple effect on the surrounding community as a result of its economic multiplier effect which is likely to create additional indirect jobs.

The IEC will help provide clean, reliable energy for Minnesota and will improve environmental conditions by allowing Minnesota to retire older plants and improve regional air quality. Combined-cycle gas-fired generation projects like IEC can operate 24 hours a day and provide grid stability vital to the use of renewable energy. Without base load producers that can regulate generation output up and down as needed, the transmission grid can't accommodate intermittent renewable generation from wind and solar facilities. Natural gas is a safe, clean source of reliable domestic energy production, and combined-cycle facilities achieve fuel efficiencies up to 60 percent. The IEC is a great example of the way we can meet our domestic energy needs, safeguard the environment and promote economic development.

The City of Cohasset will be working with Itasca County on a tax abatement plan for IEC, a company with over 120 combined years of power plant acquisition, development, construction, operational and investment experience. IEC takes pride in being a responsible corporate neighbor and citizen, and is dedicated to the environmental friendliness of natural gas, which is a cleaner alternative to many other forms of energy production.

The City of Cohasset fully supports Navasota project and is looking forward to welcoming them as the first customer in the Phase II Industrial Park.

Best Regards,

Mayor Greg Hagy

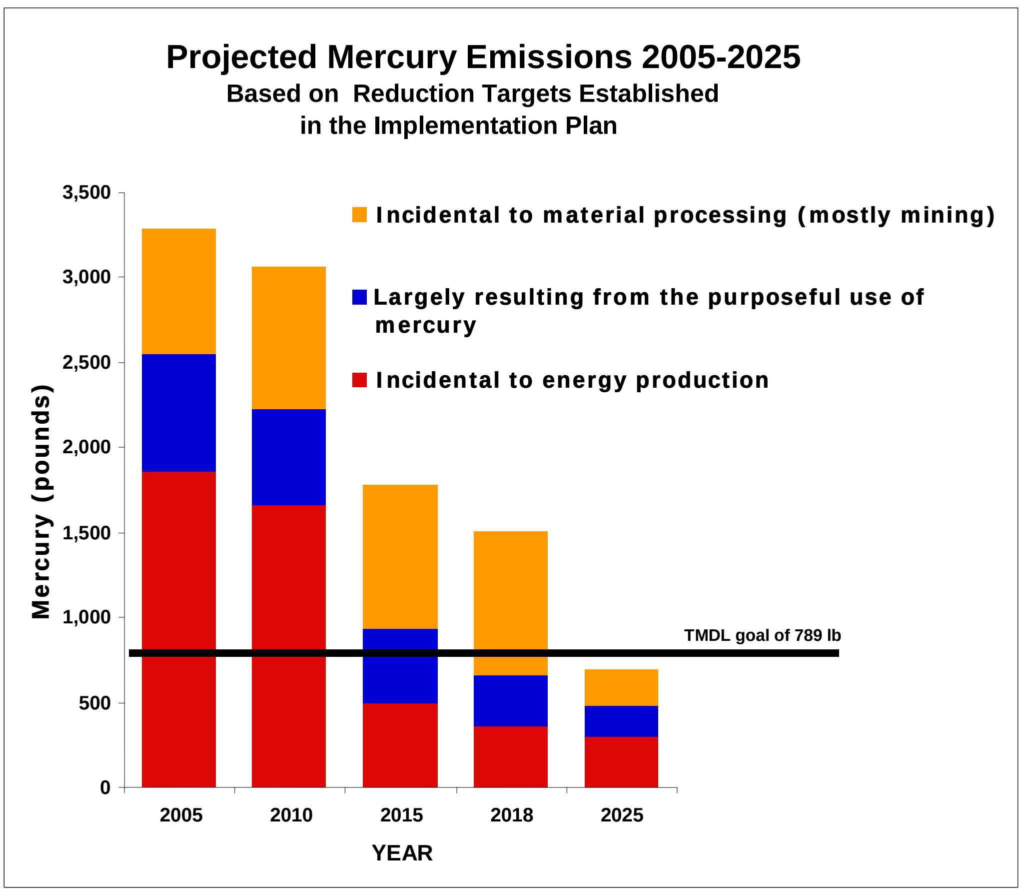
Minnesota's plan to reduce mercury releases

Minnesota Pollution Control Agency

Water quality/impaired waters 1-28 • October 2009

About two-thirds of the water impairments on Minnesota's 2006 Impaired Waters List were due to mercury. As required by the Clean Water Act, the Minnesota Pollution Control Agency (MPCA) prepared a Total Maximum Daily Load (TMDL) study that evaluated the sources of mercury and quantified the reductions needed for the mercury-impaired waters to meet water-quality standards.

Minnesota's Mercury TMDL established an annual air emission target of 789 pounds (lb.) and a water discharge limit of 24 lb. per year (lb./yr.) for Minnesota sources.



The air emission goal represents a 76 percent reduction from 2005 levels. The water limit is above current discharge levels by about 9 lb., allowing for some growth. This statewide TMDL was approved by the MPCA Board in December 2006 and by the U.S. Environmental Protection Agency in March 2007.

Stakeholders helped develop implementation plan

With substantial stakeholder input, the MPCA prepared a plan to reduce mercury releases in Minnesota. This plan, the Implementation Plan for Minnesota's Statewide Mercury Total Maximum Daily Load, describes actions Minnesota will take to meet water-quality standards for mercury. The implementation plan consists of strategies to ensure that water discharges remain below 24 lb./yr. and to reduce air emissions to below 789 lb./yr. by 2025.

The implementation plan includes:

- **Water Implementation Strategies** to ensure that total statewide mercury discharges remain below 24.2 lb./yr.
- **Air Implementation Strategies** to achieve reductions from existing sources to below 789 lb. by 2025. In addition, potential new and modified sources must implement best available controls and arrange for equivalent reductions from other sources or otherwise mitigate their increased emissions.

Minnesota Pollution Control Agency • 520 Lafayette Rd. N., Saint Paul, MN 55155-4194 • www.pca.state.mn.us
651-296-6300 • 800-657-3864 • TTY 651-282-5332 or 800-657-3864 • Available in alternative formats

- A **Monitoring and Evaluation Plan** describes the MPCA's plan for tracking the effectiveness of this Implementation Plan including air and water release monitoring as well as tracking key environmental response indicators. A stakeholder group will aid the MPCA in tracking implementation. Major progress reviews are planned every three years. View the plan at on the MPCA Web site at www.pca.state.mn.us/air/mercury-reductionplan.html.

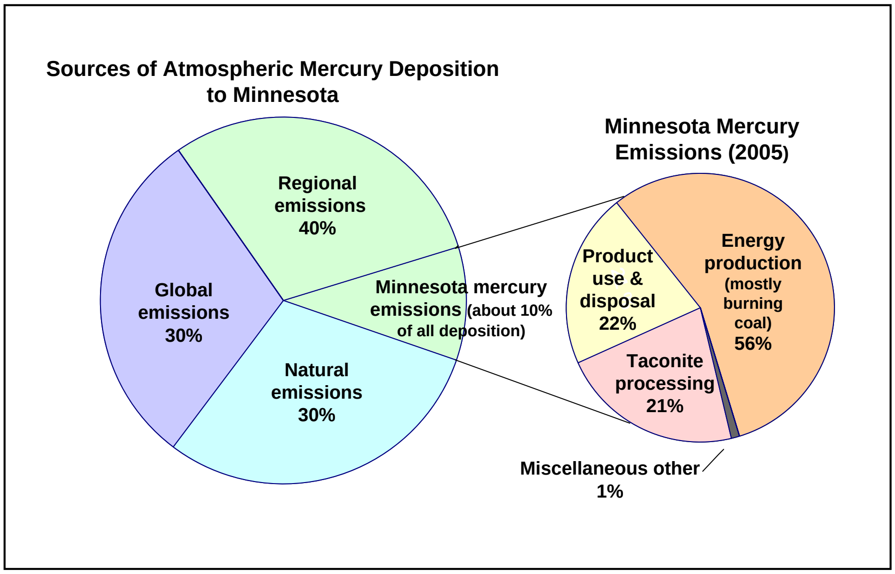
Questions about the implementation plan may be directed to Ned Brooks, MPCA mercury coordinator (phone 651-757-2247, e-mail Ned.Brooks@state.mn.us)

For more information on sources of mercury contamination in Minnesota see, the MPCA fact sheet, *Sources of mercury pollution and the methylmercury contamination of fish in Minnesota* at www.pca.state.mn.us/publications/p-p2s4-06.pdf.

Summary of Mercury Air Emission Reduction Strategies and Targets 2005-2025

Source Category	Reduction Strategy Summary*	Est. Annual Mercury Emission and Targets (lb.)			Source Reduction
		2005	2018	2025	
Coal-fired Electric Generation	70-90% reduction at all units greater than 5 lb./yr. by 2025, mostly sooner	1,716	294	235	1,481 lb./yr., 86%
Industrial, Institutional, Commercial Boilers	70% reduction at all units emitting more than 2 lb./yr.	71	33	33	38 lb./yr., 54%
Wood Combustion at Industrial Boilers	70% reduction at all units emitting more than 2 lb./yr.	31	14	14	17 lb./yr., 55%
Petroleum Refining	50% reduction by 2018, improved mass balance	13	7	7	6 lb./yr., 46%
Petroleum Product Utilization	50% reduction by 2018, improved understanding of fate	27	15	15	12 lb./yr., 44%
Smelters & Shredders That Recycle Cars & Appliances	Reduce emissions to 10 lb. by 2025, conduct testing and mass balance at largest facility.	139	20	10	129 lb./yr., 93%
Ferrous Mining/Processing	75% reduction (from 2010 estimates) by 2025, research and reporting	735	841	210	525 lb./yr., 71%
Sewage Sludge Incineration	90% control at sole uncontrolled facility	9	6	6	3 lb./yr., 33%
Recycling Mercury from Products in Minnesota	Reduce emissions to 8 lb. by 2018, conduct mass balance	65	8	8	57 lb./yr., 88%
Mercury Product Manufacturing in Minnesota	Reduce emissions to .3 lb. by 2025, quantify current emissions	42	13	0.3	42 lb./yr., 99%
Cremation	Reduce emissions to 32 lb. by 2025, improve estimates	80	63	32	48 lb./yr., 60%
Dental Preparations	Reduce emissions to 5 lb. by 2025, improve estimate	62	10	5	57 lb./yr., 92%
Sale, Use & Disposal of Mercury-containing Products	Various strategies to improve end-of-life management and decrease use	235	88	88	150 lb./yr., 64%
Emissions from Other Sources	Sources not addressed by reduction strategies	89	68	71	1 lb./yr., 20%
	Total	**3,314**	**1,464**	**734**	**2,580 lb./yr., 78%**

* Reduction percentages are from estimated 2018 levels (unless noted) and are listed to explain the basis for the target. The final target is lb./yr., not a percent reduction.



Sources of Atmospheric Mercury Deposition to Minnesota
Regional emissions 40%
Global emissions 30%
Natural emissions 30%
Minnesota mercury emissions (about 10% of all deposition)
Minnesota Mercury Emissions (2005)
Energy production (mostly burning coal) 56%
Product use & disposal 22%
Taconite processing 21%
Miscellaneous other 1%

Minnesota's Fish Contaminant Monitoring Program

Environmental Science & Technology

Policy Analysis

Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages

Walter K. Dodds, Wes W. Bouska, Jeffrey L. Eitzmann, Tyler J. Pilger, Kristen L. Pitts, Alyssa J. Riley, Joshua T. Schloesser, and Darren J. Thornbrugh

Environ. Sci. Technol., **2009**, 43 (1), 12-19 • DOI: 10.1021/es801217q • Publication Date (Web): 12 November 2008

Environmental Science & Technology is published by the American Chemical Society. 1155 Sixteenth Street N.W., Washington, DC 20036

Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages

WALTER K. DODDS,* WES W. BOUSKA, JEFFREY L. EITZMANN, TYLER J. PILGER, KRISTEN L. PITTS, ALYSSA J. RILEY, JOSHUA T. SCHLOESSER, AND DARREN J. THORNBRUGH

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Received May 20, 2008. Revised manuscript received September 16, 2008. Accepted October 3, 2008.

Human-induced eutrophication degrades freshwater systems worldwide by reducing water quality and altering ecosystem structure and function. We compared current total nitrogen (TN) and phosphorus (TP) concentrations for the U.S. Environmental Protection Agency nutrient ecoregions with estimated reference conditions. In all nutrient ecoregions, current median TN and TP values for rivers and lakes exceeded reference median values. In 12 of 14 ecoregions, over 90% of rivers currently exceed reference median values. We calculated potential annual value losses in recreational water usage, waterfront real estate, spending on recovery of threatened and endangered species, and drinking water. The combined costs were approximately \$2.2 billion annually as a result of eutrophication in U.S. freshwaters. The greatest economic losses were attributed to lakefront property values (\$0.3—2.8 billion per year, although this number was poorly constrained) and recreational use (\$0.37—1.16 billion per year). Our evaluation likely underestimates economic losses incurred from freshwater eutrophication. We document potential costs to identify where restoring natural nutrient regimes can have the greatest economic benefits. Our research exposes gaps in current records (e.g., accounting for frequency of algal blooms and fish kills) and suggests further research is necessary to refine cost estimates.

Introduction

Human-induced eutrophication is occurring throughout the world (*1*). Eutrophication reduces water quality and alters ecological structure and function of freshwaters (*2, 3*). Biological impacts of eutrophication are well understood, however degree and costs are not. Potential economic losses can be related to social, ecological, and policy-related responses (*4*).

Assigning economic value to an ecosystem function or service has been widely debated, with investigators employing a variety of methodologies (*4—7*). When reliable estimates of prospective economic losses from human-caused environmental impacts can be set, they can potentially define problems for policy makers and direct focus to areas with the greatest potential societal costs.

Lakes and rivers provide drinking water, recreation, and aesthetic benefits, all of which can be negatively influenced by eutrophication (Figure 1). Taste and odor problems increase in frequency and severity when eutrophication induces potentially toxic cyanobacterial blooms (*8*). Recreational angling and boating activities can be physically impeded by eutrophication-driven macrophyte growth and algal blooms (*8*). Water users are less likely to swim, boat, and fish during heavy algal blooms due to health risks, unfavorable appearance, or unpleasant odors (*4*). Property values can decrease with declines in water clarity (*9*). All these negative impacts can substantially influence the value of freshwater ecosystems (*3, 10, 11*).

Eutrophication management has centered on phosphorus control (*12*). Documentation of economic harm from eutrophication is limited. Characterizing costs is particularly important because the U.S. requires nutrient criteria (*13*) and other countries (e.g., the European Union Water Framework Directive) also regulate nutrients.

We investigated freshwater services where economic losses can occur from human-induced eutrophication. We first established the degree of eutrophication relative to reference nutrient conditions by U.S. nutrient ecoregion. Then we used published information to estimate potential economic losses with respect to recreational water usage, waterfront property values, threatened and endangered species recovery efforts, and spending on drinking water.

Methods

Current and Reference Nutrients. The U.S. Environmental Protection Agency (EPA) collected total nitrogen (TN) and total phosphorus (TP) data from rivers and streams (hereafter rivers) and lakes and reservoirs (henceforth lakes) for the National Nutrient Strategy aggregated level III ecoregions, (hereafter referred to as nutrient ecoregions; *14, 15*). Ambient data came from the EPA Legacy and STOrage and RETreival (STORET) data system, U.S. Geological Survey National Stream Quality Accounting Network (NASQAN), and the National Water Quality Assessment (NAWQA; (*16*)). For this data set, the EPA collected nutrient data from a representative sample of the population of water bodies in each nutrient ecoregion, and data reduction methods were used to prevent

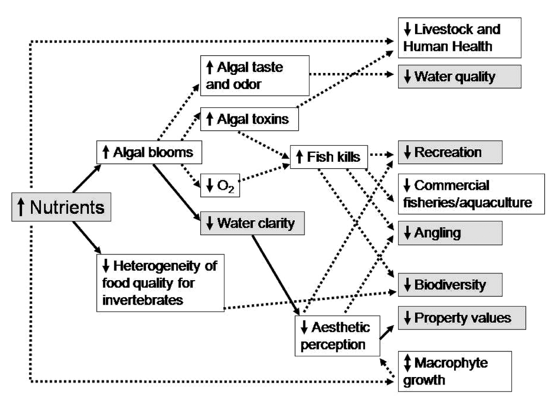

FIGURE 1. Some effects of increased nutrients that could influence the value of freshwater ecosystem goods and services. The values we could assign are in gray, the solid lines indicate the chain of influence we used to calculate the values. Some other pathways are discussed in the text as well. More indirect methods were required to calculate some other effects (see Methods for details).

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10.1021/es801217q CCC: \$40.75

Published on Web 11/12/2008

TABLE 1. Reference and Current Median TP and TN Concentrations for Rivers in Each Nutrient Ecoregion during Summer Months[a]

ecoregion	ecoregion name	reference TP median $mg \cdot L^{-1}$	current TP median $mg \cdot L^{-1}$ (*N*)	% of rivers > reference median	reference TN median $mg \cdot L^{-1}$	current TN median $mg \cdot L^{-1}$ (*N*)	% of rivers > reference median
I	Willamette and Central Valleys	0.016	0.088 (178)	96	0.121	0.301 (16)	76
II	Western Forested mountains	0.019	0.026 (1380)	60	0.147	0.248 (239)	69
III	Xeric west	0.021	0.055 (808)	75	0.041	0.561 (153)	100
IV	Great Plains grass and shrublands	0.046	0.087 (341)	67	0.081	0.956 (65)	100
V	Central cultivated Great Plains	0.049	0.184 (489)	86	0.191	1.283 (94)	100
VI	Corn belt and Northern Great Plains	0.052	0.168 (815)	90	0.313	3.372 (77)	100
VII	Mostly glaciated dairy region	0.022	0.080 (910)	87	0.139	0.928 (125)	99
VIII	Nutrient poor glaciated upper Midwest and Northeast	0.013	0.021 (608)	65	0.156	0.566 (72)	97
IX	Southeastern temperate forested plains and hills	0.048	0.080 (2104)	68	0.141	1.457 (274)	99
X	Texas-Louisiana costal and Mississippi alluvial plains	0.048	0.176 (295)	99	0.339	1.019 (36)	92
XI	Central and Eastern Forested uplands	0.020	0.022 (1591)	53	0.148	0.712 (290)	94
XII	Southern coastal plain	0.025	0.103 (466)	85	0.521	1.216 (90)	99
XIII	Southern Florida coastal plain	0.036	0.080[b]	87	0.631	2.666[b]	100
XIV	Eastern coastal plain	0.015	0.077 (375)	95	0.540	1.141 (56)	88

[a] *N* is the number of stations providing data used for estimating current nutrient distributions. The percentage of current rivers whose TP and TN concentration is greater than the reference median was calculated as one minus the percentile of the estimated reference median in the estimated current distribution. [b] No gauging stations available. Current values estimated by regression, see Methods.

biased records from water bodies with a greater number of samples than others. In particular, each water body was represented by the median concentration of all samples taken from that river or lake. Laboratories used standard methods or U.S. EPA certified methods and were required to employ QA/QC procedures. Distribution of median water body nutrient concentrations from the EPA's nutrient data was ascertained for each water body type (i.e., rivers and lakes) in all nutrient ecoregions. All statistical analyses were conducted by nutrient ecoregion.

Reported TN and TP percentile concentrations were used to estimate the log-normal distribution of nutrient concentrations. Distributions for summer months were used because that is generally when effects of eutrophication are most extreme. Percentile values (5th, 25th, 50th, 75th, and 95th percentiles) were fitted to a cumulative log-normal distribution using the Solver add-in for Microsoft Excel by minimizing the sums of squares of differences between observed cumulative probability (EPA percentiles) and calculated cumulative probability (with mean (μ) and standard deviation (σ) of log transformed values). This solving approach allowed us to construct continuous frequency distributions from the estimate mean (μ_{river} and μ_{lake}) and standard deviation (σ_{river} and σ_{lake}) of the natural log of TN and TP concentrations for rivers and lakes.

A total of 1587 and 10360 stations were used to estimate current TN and TP concentration distributions, respectively, in rivers from all but nutrient ecoregion XIII (Table 1). Data for current TN and TP concentration distributions in lakes came from 980 and 5200 stations, respectively, in all nutrient ecoregions except I and X (Table 2). Linear regression of μ_{lake} vs μ_{river} for all other nutrient ecoregions was used to estimate current μ_{lake} for nutrient ecoregions I and X and μ_{river} for ecoregion XIII. For TP, the equation was $\mu_{river} = (0.69)\ \mu_{lake} - 1.60$ ($P = 0.003$; adjusted $R^2 = 0.61$). The equation we used to estimate mean TN in lakes of ecoregions I and X was $\mu_{river} = (0.71)\ \mu_{lake} - 0.34$ ($P = 0.006$; adjusted $R^2 = 0.53$). We assumed the ratio of μ_{lake}:σ_{lake} = μ_{river}:σ_{river} and used this relationship to estimate σ_{lake} for these ecoregions. Using log-normal frequency distributions defined by μ and σ allowed us to predict the proportional occurrence of water bodies for any value of TN or TP concentration within each ecoregion and to compare to proportional occurrence under reference conditions.

Reference means and standard deviations for TP and TN in rivers were taken from Smith et al. (*17*) who modeled background nutrient concentrations in rivers and corrected for atmospheric N deposition. Smith et al. (*17*) provided 10th, 25th, 50th, and 90th percentiles for all ecoregions. We estimated μ and σ from these data using the Excel Solver method described for EPA current nutrient distributions in the previous section.

To our knowledge, there is no comprehensive study estimating lake reference nutrient conditions across multiple ecoregions. In the absence of this information, we assumed river nutrient concentrations were directly proportional to lake concentrations within ecoregion. The assumption is reasonable because (1) rivers are the water and nutrient source for lakes, and (2) significant relationships were identified between current concentrations in lakes and those in rivers for both total N and P (see results). We estimated reference μ_{lake} for each ecoregion assuming reference μ_{river}/current μ_{river} = reference μ_{lake}/ current μ_{lake} within each nutrient ecoregion. We also assumed ratio of reference (μ_{river}:σ_{river}) was equal to reference ratio (μ_{lake}: σ_{lake}) to calculate σ_{lake} from known μ_{lake} within each ecoregion. Estimated μ and σ for reference and current distributions were used to estimate percentage change in TN and TP concentrations for each ecoregion. The mean of a log-normal distribution is not recommended as a measure of central tendency (*18*),

TABLE 2. Reference and Current Median TP and TN Concentrations for Lakes in Each Nutrient Ecoregion during Summer Months[a]

ecoregion	ecoregion name	reference TP median $mg \cdot L^{-1}$	current TP median $mg \cdot L^{-1}$ (*N*)	% of lakes > reference median	reference TN median $mg \cdot L^{-1}$	current TN median $mg \cdot L^{-1}$ (*N*)	% of lakes > reference median
I	Willamette and Central Valleys	0.007	0.038[b]	91	0.122	0.305[b]	77
II	Western Forested mountains	0.014	0.019 (296)	61	0.147	0.249 (45)	65
III	Xeric west	0.011	0.029 (170)	75	0.039	0.537 (24)	100
IV	Great Plains grass and shrublands	0.026	0.050 (127)	70	0.126	1.489 (2)	99
V	Central cultivated Great Plains	0.023	0.085 (213)	85	0.211	1.416 (2)	100
VI	Corn belt and Northern Great Plains	0.025	0.080 (393)	87	0.159	1.708 (3)	100
VII	Mostly glaciated dairy region	0.010	0.038 (787)	85	0.120	0.800 (35)	100
VIII	Nutrient poor glaciated upper Midwest and Northeast	0.007	0.012 (1238)	76	0.091	0.330 (159)	100
IX	Southeastern temperate forested plains and hills	0.024	0.040 (727)	68	0.052	0.537 (24)	100
X	Texas-Louisiana costal and Mississippi alluvial plains	0.016	0.061[b]	92	0.241	0.725[b]	100
XI	Central and Eastern Forested uplands	0.018	0.019 (267)	53	0.124	0.593 (14)	99
XII	Southern coastal plain	0.005	0.020 (692)	93	0.318	0.743 (545)	94
XIII	Southern Florida coastal plain	0.016	0.035 (10)	81	0.340	1.435 (7)	100
XIV	Eastern coastal plain	0.003	0.017 (280)	98	0.218	0.460 (120)	94

[a] *N* is the number of stations providing data used for estimating current nutrient distributions. The percentage of current lakes whose TP and TN concentration is greater than the reference median value was calculated as one minus the percentile of the estimated reference median in the estimated current distribution. [b] No data available. Current values estimated by regression, see Methods.

therefore median values were used to estimate actual change in TN and TP concentrations for each ecoregion.

The following sections describe estimated annual economic losses from eutrophication. Equations used when cost estimates were possible are summarized in the Supporting Information.

Recreation and Angling Costs. We first estimated increase in lake area closure due to eutrophication. Prolific algal and cyanobacterial blooms are most common during summer months, therefore, we assumed that all lakes classified as hypereutrophic (TP > 100 μg $TP \cdot L^{-1}$; (*19*)) during this time period would be closed or not used for recreational activities for one (31 days) to three months (92 days). We used hypereutrophic status to indicate lake closures because the probability of a cyanobacterial bloom is 0.90 above 100 μg $TP \cdot L^{-1}$ (*20*). The proportion of reference lakes expected to be hypereutrophic under reference conditions was subtracted from the proportion of lakes currently hypereutrophic. Lake surface area for each nutrient ecoregion was calculated by using ESRI data in ArcGIS (*15*).

Value losses to recreational boating and angling were estimated by calculating loss of trip-related expenses only (e.g., travel, lodging, fuel, food, bait). Per-trip boating-related expenses were assumed to be representative of all ecoregions (*21*), and scaled to 2001 pricing (*22*). The number of day visits per water body type was assigned using the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (*23*), and the 2002 National Recreational Boating Survey Report (*24*) was used to identify total number of boating days by water body type. Number of fishing and boating days in 2001 was considered the realized use because a portion of lakes were closed to recreational use (i.e., 1−3 months) because of eutrophication. Therefore, current level of use does not represent the full potential of lakes to attract recreational users. Potential use was estimated from realized use during the summer months and scaled by proportional increase in hypereutrophic lake area (PI_l, Supporting Information). Potential number of recreational days was distributed proportionally among each ecoregion according to lake surface area because realized use was surveyed at the national level and hypereutrophic status was calculated by ecoregion. Number of closed days-per-year was calculated for recreational angling and boating separately by ecoregion.

Lake Property Values. Secchi depth strongly correlates with property values (*4*). We used data from 37 lakes in the Mississippi River headwaters region (*9*) to calculate percent gain or loss in property values per 1 m change in Secchi depth. Median TP and the equation from Nürnberg (*29*) were used to estimate reference and current Secchi depths in each ecoregion. Increase in nutrient concentrations above reference conditions over the last 50 years was assumed to be a result of eutrophication (*25*). Therefore, to calculate annual property value loss (PVL), total change in property value was divided by 50 years (Supporting Information).

Total lake frontage (km) in each ecoregion was calculated using ESRI data in ArcGIS (*15*). Of the total lake perimeter in the U.S., we could not determine proportion of private ownership. Therefore we calculated costs for three levels of private ownership around lakes (5, 25 and 50%). Value changes along rivers as a result of water quality changes are unknown and were not calculated.

Loss of Biodiversity. Eutrophication decreases diversity and richness of aquatic macroinvertebrates (*26, 27*), fish (*27*), and aquatic primary producers (*28*). Value of total diversity is difficult to quantify so we used threatened and endangered species recovery plan costs. Richter et al. (*29*) reviewed 135 imperiled freshwater species and found nutrient regimes as a major stressor in 30% of historical and 25% of currently imperiled species cases. We assumed that 25% of all imperiled aquatic species are threatened in part by human-induced eutrophication and therefore 25% of all recovery costs from U.S. Federal Endangered Species Act plans can be attributed to impacts of human-induced eutrophication, scaled to 2001 values (*22*).

Drinking Water Treatment Costs. Algal and cyanobacterial blooms cause taste and odor problems in drinking water (*8*). Drinking water costs attributable to eutrophication were estimated using the amount of money spent on bottled water that could potentially be attributed to avoidance of taste and odor problems in surface-water-derived tap water (Supporting Information). Data were not available to calculate total costs of drinking water treatment. We assumed that groundwater does not have taste and odor issues related to eutrophication and that most taste and odor problems in surface waters were related to algal metabolites (*30*). A survey of 241 water facilities (*31*) found that 82% of those surveyed had taste and odor issues related to algae.

Survey. We surveyed appropriate agencies from 14 states representing 13 nutrient ecoregions to better understand the perceived degree to which rivers and lakes have become eutrophic and how these problems are addressed. Questions were asked about the number of days water bodies were closed for contact and noncontact use, number of fish kills, human and livestock deaths and sicknesses, money spent on watershed restoration and developing nutrient criteria, money spent on macrophyte removal, and water treatments added by municipalities as a result of eutrophication (Supporting Information). While the survey results were not reliable enough to use in our possible economic cost analyses, we characterized variability in eutrophication management across states.

Results

Current TN and TP means for rivers significantly correlated with those for lakes justifying their use to predict lake TN and TP for the ecoregions where current lake data were missing (Supporting Information). This positive relationship also indicates that using reference river concentrations to predict reference lake concentrations was reasonable.

All nutrient ecoregions had current median TP concentrations greater than medians under reference conditions. Current TP medians exceeded reference medians across ecoregions by 0.002−0.134 $mg \cdot L^{-1}$ (1.1−5.6 with a mean of 3-fold higher) for rivers and 0.002−0.072 $mg \cdot L^{-1}$ for lakes (Tables 1 and 2). In 9 of 14 ecoregions, over 80% of rivers currently exceed median reference values. In ecoregions I, VII, and X, current and reference TP distributions in rivers were similar in shape but shifted to greater concentrations (Figure 2). All other ecoregions had a wide range of TP concentrations. This, along with a greater proportion of rivers with higher concentrations, produced broader cumulative distributions. In general, estimated reference distributions were narrow (i.e., having a narrower range of concentrations) compared to current distributions.

All nutrient ecoregions had current median TN concentrations greater than reference conditions. Current exceeded reference median values across ecoregions by 0.04−3.06 $mg \cdot L^{-1}$ (1.2−13 fold, mean of 5.5 times greater) for rivers and 0.04−1.55 $mg \cdot L^{-1}$ for lakes (Tables 1 and 2). In 12 of 14 ecoregions, over 90% of rivers currently exceed median reference values. Nutrient ecoregions III, IV, VI, IX, and X had current river nutrient distributions with shape similar to that of the reference distributions, but shifted to higher TN concentrations (Figure 3). All other ecoregions had rivers with current TN cumulative distributions broader than reference distributions and contained a greater percentage of rivers with higher TN concentrations.

The closure of lakes to recreational angling and boating because of hypereutrophic conditions resulted in substantial losses of trip-related expenditures. Lakes with hypereutrophic conditions increased in each ecoregion, up to 43% over reference conditions (Figure 4). Numbers of realized fishing and boating day visits were approximately 300 and 443 million per year, respectively. Total recreational use days (i.e., realized + potential use) were estimated at 450−465 and 305−315 million fishing and boating days respectively, of which 7.1−22.2 and 4.8−15.0 million days were potentially lost to eutrophication each year, depending on length of lake closure. Trip-related expenditures per day were estimated at $26.60 for fishing and $37.83 for boating, resulting in annual losses of $189−589 and $182−567 million, respectively. Annual value loss from eutrophication combined for recreational angling and boating could reach $1.16 billion. Ecoregion VI contributed half the total value loss.

All ecoregions had a calculated decrease in Secchi depth from reference values and had lower property values. At the low (5% private), intermediate (25% private), and high (50% private) assumed land availability, eutrophication losses were $14.1, $70.6, and $141.1 billion, respectively. When scaled by 50 years, average rates were $0.3, $1.4, and $2.8 billion in cost per year, respectively (Figure 5).

According to the 2007 U.S. Fish and Wildlife Endangered Species database, 139 fish, 70 mussels, 4 crayfish, 23 amphibians, and one dragonfly had endangered or threatened status (www.fws.gov). Of these, 156 species are covered in 112 recovery plans initiated between 1981 and 2007. We estimate 60 currently listed species are at least partially imperiled due to eutrophication (*29*). The average annual cost of 60 plans was $732,800 suggesting $44 million per year is spent to prevent eutrophication-linked losses of aquatic biodiversity.

Five billion gallons of bottled water were sold during 2000, and 27.7% of people polled purchased bottled water as a result of tap water taste issues (*32*). Bottled water cost $0.89 per gallon in 2003 and surface water sources supply 66% of U.S. domestic water. We estimate $813 million is spent annually on bottled water because of taste and odor problems potentially linked to eutrophication. This estimate is based purely on bottled drinking water costs and does not take into account additional costs related to alternative drinking water treatments such as wells or hauling drinkable water from another area. We were unable to obtain an accurate estimate of the amount of money spent on treating drinking water because not all water treatment facilities separate these costs from treating drinking water for reasons unrelated to eutrophication. Therefore, $813 million is probably an underestimate of the total cost of treating drinking water due to eutrophication.

Based on our informal survey, we found that many water quality parameters are not tracked in a comparable manner across the U.S. Only 3 of 13 states surveyed tracked the number of algal-bloom-related lake closures. Some of the states we surveyed kept more quantitative records than others which resulted in most of our answers coming from only a few states. The small number of states with detailed records made it difficult to extrapolate survey results to the rest of the U.S.

Discussion

Human-induced eutrophication has substantially increased TP and TN concentrations in U.S. rivers and lakes. All nutrient ecoregions now have median TP and TN concentrations greater than reference values for rivers and lakes. Even ecoregions with similar medians have a greater proportion of rivers and lakes with higher nutrient concentrations than reference conditions. Reference criteria for rivers were studied by both Smith et al. (*17*) and Dodds and Oakes (*33*). Both studies produced similar results using different methods.

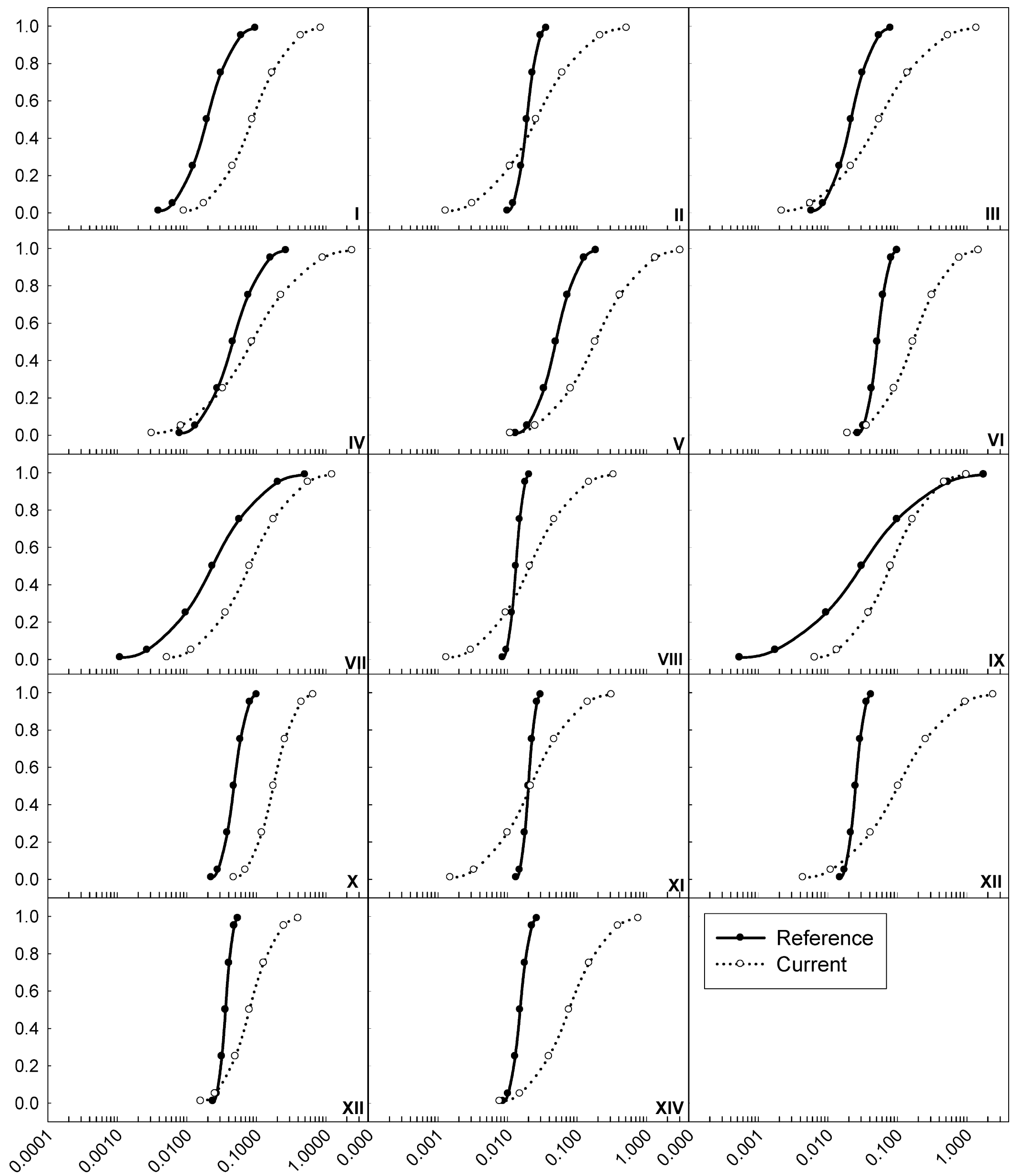

FIGURE 2. Cumulative frequency of total phosphorus for reference (filled circles) and current (open circles) conditions in rivers by nutrient ecoregion (as indicated by roman numerals).

Their similar results support our findings of increased nutrient concentrations across all ecoregions. Without an existing comprehensive study on reference conditions for lakes and reservoirs, we had greater confidence in river distributions than those for lakes derived from previous estimates. Still, rivers in an ecoregion form the major source of nutrients for lakes in that ecoregion. Dodds et al. (*34*) estimated reference values for reservoirs in Ecoregions IV, V, and VI of 23, 27−62, and 15 $\mu g \cdot L^{-1}$ TP, respectively, and our estimates were 23, 13, and 15 $\mu g \cdot L^{-1}$ respectively, showing moderate agreement.

We expect that the degree of eutrophication documented in the U.S. represents a global phenomenon. A substantial portion of nutrients from human-induced eutrophication are ultimately derived from fertilizers, and fertilizer use patterns can be used to indicate global trends of eutrophication. Bumb and Baanante (*35*) predict continued increase in fertilizer use over the next 20 years, with greater increases in developing countries.

Over $1 billion in recreation expenditures were estimated lost annually, yet our methods could not account for all recreation losses and required several assumptions. We assumed that users do not substitute a nearby lake with lower nutrient loadings for a "closed" hypereutrophic lake. The scale of our data required that we assume water body use was evenly distributed throughout the year, when in fact most use and most algal blooms occur during the summer months (*24*). Further, we had to assume that values for angling and boating daily trip expenditures were representative across all ecoregions, and could be extrapolated to the entire U.S. We were unable to account for losses from the Great Lakes region (54 million fishing/boating days) or rivers (260 million fishing/boating days), because of difficulty estimating frequency of algal blooms in these water bodies. Our calculations did not include equipment purchases that would decline in areas where recreational opportunities decrease because of eutrophication.

Clear water is aesthetically pleasing and lakefront property has significantly greater value with increased clarity (*9*, *36*); a decrease in property value of 15.6% occurs with every 1-m loss in Secchi depth (*9*). Thus, we predict substantial losses in the value of U.S. lakefront property. These losses are probably underestimates because nationally reported me-

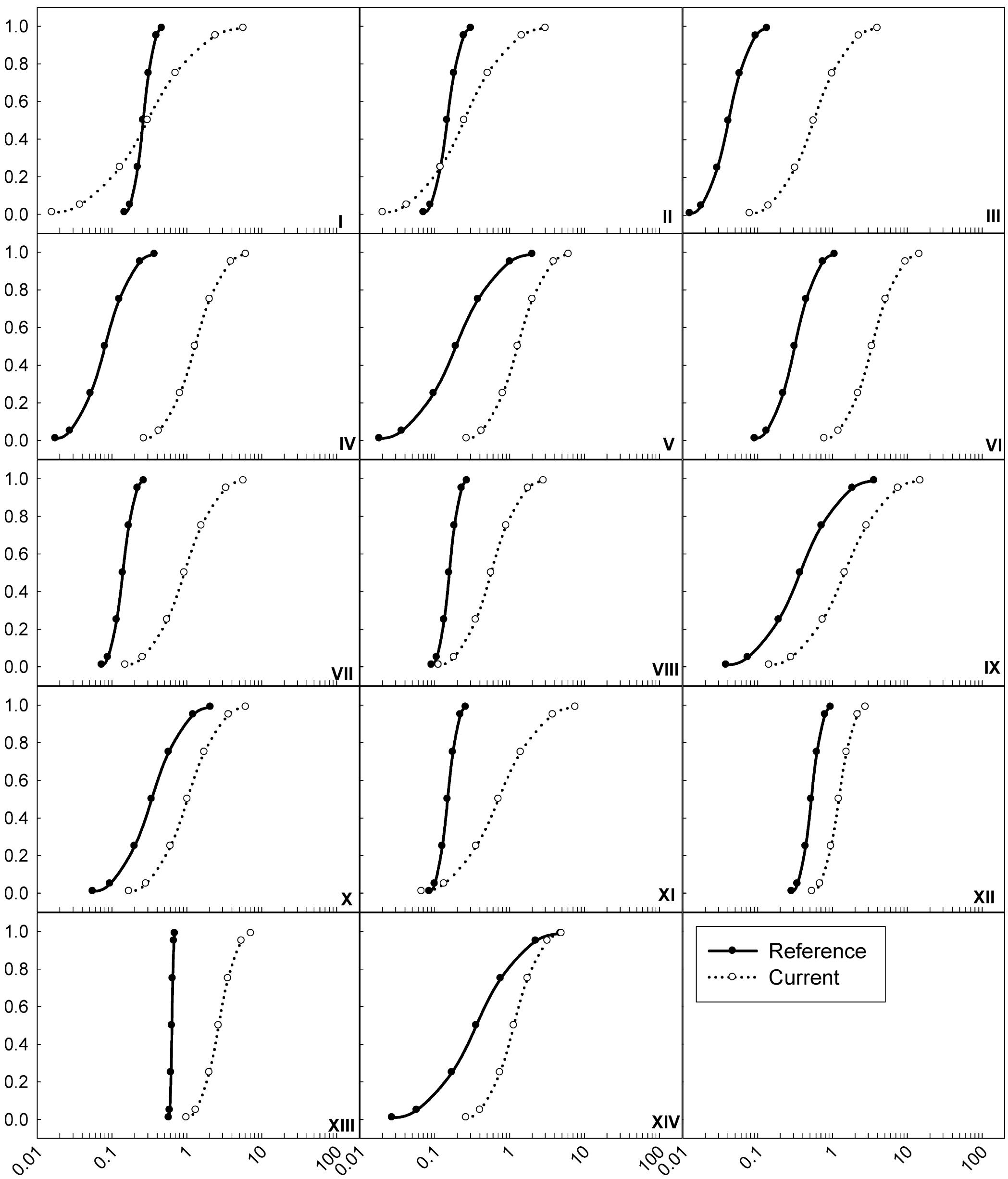

FIGURE 3. Cumulative frequency of total nitrogen for reference (filled circles) and current (open circles) conditions in lakes by nutrient ecoregion (as indicated by roman numerals).

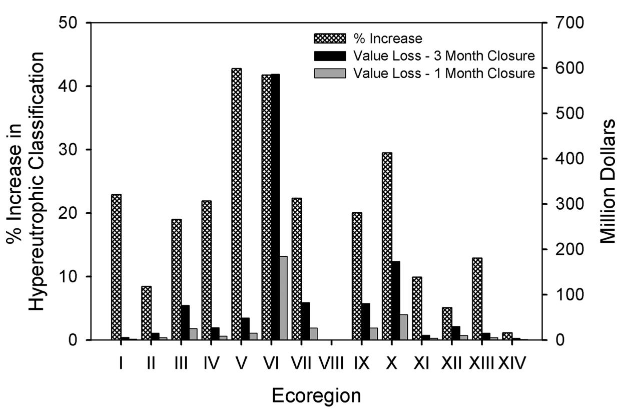

FIGURE 4. Percent increase in hypereutrophic status for lakes, reservoirs, and ponds and the combined annual fishing and boating value loss with a 3 or 1 month summer closure period for each ecoregion.

dians for each ecoregion might not accurately represent waterfront properties. Waterfront properties in the United Kingdom are worth 10−40% more than equivalent nonwaterfront properties (*36*). Also, water clarity affects property values up to 1.2 km from the shoreline (*37*) but we only considered adjacent property.

Altered nutrient regimes are one of many stressors leading to species endangerment, but we consider \$44 million/year a highly conservative estimate for loss of biodiversity because it underestimates the true value of altering natural species assemblages (i.e., local extirpation of diversity does not lead to federal listing). Human-perceived aesthetic values of biodiversity, ecosystem services, and local losses of fairly common species that would not be recognized as threatened or endangered (e.g., those listed as threatened or endangered at the state level) were not included in our estimate. We also expect some species will eventually be listed as endangered as a result of current activities. For instance, many unionid mussels continue to decline even though management actions have not substantially changed over the last few decades (*38*).

Eutrophic systems have more taste and odor problems from eutrophication. Arruda and Fromm (*39*) reported a

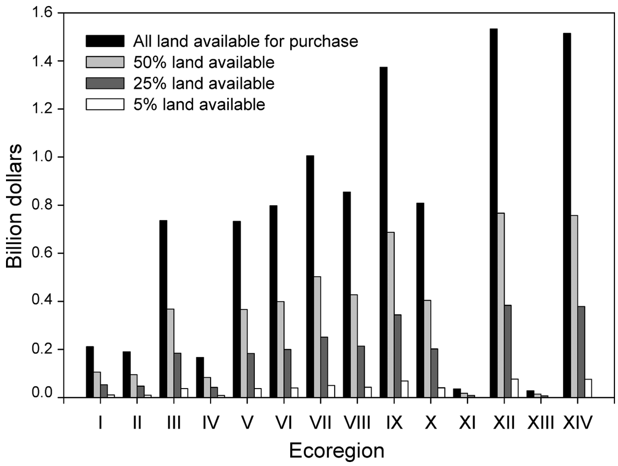

FIGURE 5. Property value lost per year by ecoregion due to changes in Secchi depth from increased phosphorus loadings into lakes. Value lost was calculated assuming all land around lakes, reservoirs and ponds is available, 50% is available, 25% is available, and 5% is available for private land ownership.

strong positive linear relationship between odor rank, trophic state, and mean chlorophyll concentration in Kansas lakes. Our estimate of drinking water costs does not account for additional drinking water treatment costs related to taste and odor problems. In 1976 the US EPA set aside $7.5 million, and in 2004 set aside $102 million, for the Public Water System Supervision program (*40*). The Drinking Water Infrastructure Needs Survey concluded that $150.9 billion will need to be invested in drinking water systems to provide safe treatment, storage, and distribution (*40*). Eutrophication is a major component of taste and odor problems that this funding partially addresses through drinking water supervision and infrastructure development.

Macrophyte abundance increases with greater nutrients until conditions become hypereutrophic and algal blooms dominate the water column (*12*). Management of overabundant macrophytes is necessary because they restrict navigation, recreation, and lake processing (*41*), and detract from aesthetic appeal. Treatment costs for a variety of aquatic weeds range from $1,247 to $19,227 per hectare for mechanical harvest and $246 to $1,190 per hectare for chemical treatment (*41*−*43*). If just 1% of major surface waters (approximately 162,384 ha; (*15*)) in the U.S. needed macrophyte control because of eutrophication-induced excessive growth, it would cost an average of $1.2 billion annually for mechanical harvest or $105 million dollars annually for herbicide treatment.

Eutrophication can be beneficial to fisheries as fish biomass increases with primary production (*44*). However, under hypereutrophic conditions, more valuable fishes are often replaced by undesirable "rough" fishes (*44*). Commercial aquaculture (*45*) was assumed to not be negatively impacted by eutrophication. The majority of freshwater commercial fishing occurs on the Laurentian Great Lakes (*46*). Despite problems with eutrophication (*47*), the overall economic value of commercial fishing in the Great Lakes has remained relatively stable, independent of nutrient fluctuations.

Algal blooms as a result of eutrophication have caused harmful health effects to humans and livestock (*48*). Mass mortalities of wildlife have been attributed to cyanobacterial blooms (*49*). For humans, algal blooms cause sicknesses and rarely result in death (*50*). We did not include human health costs because they appear to be minor compared to other factors we investigated. Still, people might be more likely to spend considerable amounts to avoid toxic blooms.

Trends in nutrient concentrations across the continental U.S. have been well documented (*51*−*53*), but not compared to reference conditions. We estimated current nutrient concentrations related to reference conditions, and tied these to economic costs where possible. We provide broad annual estimates of economic losses in recreational water usage ($1 billion), waterfront property ($0.3−$2.8 billion), recovery of threatened and endangered species ($44 million), and drinking water ($813 million), resulting from human-induced eutrophication. These potential losses total over $2.2 billion annually and our estimates are probably conservative.

Our study shows some areas where research should be focused and where better records should be kept. Accounting for eutrophication-related drinking water costs, as well as macrophyte-removal costs resulting from increased nutrient loading, is needed. Accounts of fish kills associated with eutrophication and the negative impact of enriched waters on biodiversity as a whole are lacking. Agricultural production and fertilizer use will likely increase (*54*), resulting in intensified eutrophication-related losses. Trajectories of reactive nitrogen loadings worldwide show increases in freshwater transport of 21 million tons in preindustrial times to 40 million tons per year today, while riverine transport of dissolved inorganic nitrogen has increased from 2−3 million to 15 million tons (*55*). Our estimates could help society quantify potential costs associated with increased nutrients entering freshwater ecosystems, but more importantly highlight the value of clean water to society.

Acknowledgments

We thank Dolly Gudder, David Hoeinghaus, Craig Paukert, Keith Gido, and the KSU aquatic journal club for helpful comments on the manuscript. This is publication 08-351-J from the Kansas Agricultural Experiment Station.

Supporting Information Available

(1) Table of all equations used to calculate values, (2) a table with costs for macrophyte removal, (3) a table summarizing the results of surveying state agency personnel about eutrophication and costs, and (4) figures documenting the positive relationships for current total phosphorus in rivers and lakes and current total nitrogen in rivers and lakes. This information is available free of charge via the Internet at http://pubs.acs.org.

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ES801217Q

A NUTRIENT WATER QUALITY ASSESSMENT

of the

LAKES: BIG WOLF, ANDRUSIA, CASS

and

WINNIBIGOSHISH

JANUARY 2001

A JOINT EFFORT BETWEEN
the
LEECH LAKE BAND OF OJIBWE
and
BELTRAMI COUNTY

Report Preparation by John Persell

Point sources of pollution in the study area include the city of Bemidji's municipal sewer treatment plant (STP), which discharges to the Mississippi River approximately ten (10) miles above Big Wolf Lake. This STP was newly constructed in 1984 as a state of the art facility designed to achieve 0.3 milligrams per liter of phosphorus in the treated effluent. During the several decades preceding the new STP, many tons of phosphorus were loaded to, and adversely impacted, Big Wolf, Andrusia and Cass lakes.

The city of Cass Lake also discharged treated sewage into the contiguous waters of this study until 1984. The city of Cass Lake's STP discharged into Fox Creek, a tributary to Pike Bay. Pike Bay flows to Cass Lake via Pike Bay Creek. In 1984, the city of Cass Lake converted their sewage treatment facility to land irrigation, eliminating any discharge to surface water.

The only other NPDES facility in the study area is the Champion International (recently purchased by International Paper) Superfund Site in the city of Cass Lake. This Site is near the shore of Pike Bay and Pike Bay Creek. Champion discharges charcoal treated effluent into Pike Bay Creek. The effluent comes from a groundwater pump and treat operation which is part of a Site reclamation effort. This Site was a wood treatment operation from 1957 to 1984, utilizing several chemicals including pentachlorophenol (PCP), creosote, fuel oil, and copper-chromium-arsenate (CCA). During some years of operation, nutrients were added to Site pond waters in an effort to stimulate the biological breakdown of the organic wastes in the ponds. Some Site wastes are known to have been discharged into the city's sanitary sewer, and Site runoff waters likely ran downhill to Pike Bay Creek.

Lake Morphometry

Big Wolf lake has a surface area of 1051 acres and an average depth of approximately 22.7 feet (Trihey, 1981). The maximum depth is approximately 56 feet, and the volume is 23,858 acre-feet. The watershed area of Big Wolf lake is 631 square miles. The Mississippi River enters and exits the lake in the northern end, indicating incomplete mixing of the incoming river volume with the volume of the lake, as noted by Trihey. The hydraulic flush time of the lake (Tw) in this study period was 35 days (51 days in 1991). Lakeshore development includes 68 dwelling/campsites, including 6 resort/campgrounds. Approximately 20 of the dwellings are homes for permanent lakeshore residents.

Lake Andrusia is the next lake downstream on the Mississippi River, approximately one mile below Big Wolf lake. The surface area of lake Andrusia is 1,510 acres, the average depth is 24.6 feet, maximum depth 60 feet and the lake volume is 37,202 acre/feet. The watershed area of lake Andrusia is 694 square miles. The Mississippi River enters and exits lake Andrusia in the southeast portion of the lake. Mixing of the river and lake volumes is thought to be more substantial than in Big Wolf lake, however complete mixing of the two volumes is unlikely in most years (Tw=51 days, 2000; 69 days in 1991). The shoreline development of lake Andrusia includes 78 dwelling/campsites, comprised of 6 resort/campgrounds, and 22 permanent lakeshore dwellings.

Watershed management practices should be maintained, or undertaken as the case may be, to ensure that the desired lake and stream uses are achieved. Failure to do so may result in water quality degradation which will impact uses, including the following:

1. Decreased availability of surface waters for cultural and spiritual purposes.

2. Aquatic life: shifts in abundance and types of organisms from diverse and desirable to low diversity and undesirable; increases in the abundance of fish in a water body, but a change in the type of fish to less desirable species (USEPA, 1986; Ogelsby, 1987), decreased recruitment due to an increase in fish diseases (Hoffman, 1976), and parasitism (Persell, 1985).

3. Swimming: safety problems due to limited transparency; discomfort due to skin irritations associated with insects and parasites (USEPA, 1986).

4. Boating: interference due to abnormal abundance of plants (USEPA, 1986).

5. Aesthetics: unattractive conditions, odors, insects (USEPA, 1986).

Feasible Water Quality Management Alternatives

A. No Further Action

No water quality management action in this watershed resulted in an overload of nutrient loading to Big Wolf, Andrusia, Cass lakes. This overload of nutrients, particularly phosphorus, accelerated the eutrophication of the lakes, changing their beneficial productivity to unhealthy nuisance conditions. This degradation was fully recognized in the decade of the 1970s, and actions were taken to remedy the situation. The management of nutrients in the watershed is taking place for some sources and in some areas of the watershed. Examples of this are NPDES permitting and urban runoff control practices. Many government agencies, citizen groups, and businesses have adopted good stewardship policies regarding potential human impacts to land and water resources. These include soil conservation, forest harvest, agricultural runoff, and lakeshore septic standards. Many of these policies are voluntary. No further action is feasible, if only because no output of public funds is required to accomplish nothing. The downside of no further action would be a slowing, or stalemate, of the learning curve on these nutrient management challenges.

Enbridge Pipelines in Minnesota: Fueling Minnesota's economic engine

Enbridge's energy infrastructure has helped fuel quality of life in Minnesota for more than 65 years. Enbridge pipelines deliver the products that heat homes and businesses, fuel vehicles, and power industry across the state.

Line 1
A 1,098-mile pipeline carrying NGL and light crude from Edmonton, Alberta to Superior, Wis.

Line 2B
A 502-mile pipeline from Cromer, Manitoba to Superior, Wis. carrying light crude. Line 2A, a 24" pipeline, originates in Edmonton, Alberta and connects with line 2B in Cromer.

Line 3**
A 1,097-mile pipeline carrying primarily light crude from Edmonton, Alberta to Superior, Wis. (The existing Line 3 will be deactivated following in service of the Line 3 Replacement).

Line 4
A 1,098-mile pipeline carrying a variety of crude oil from Edmonton, Alberta to Superior, Wis.

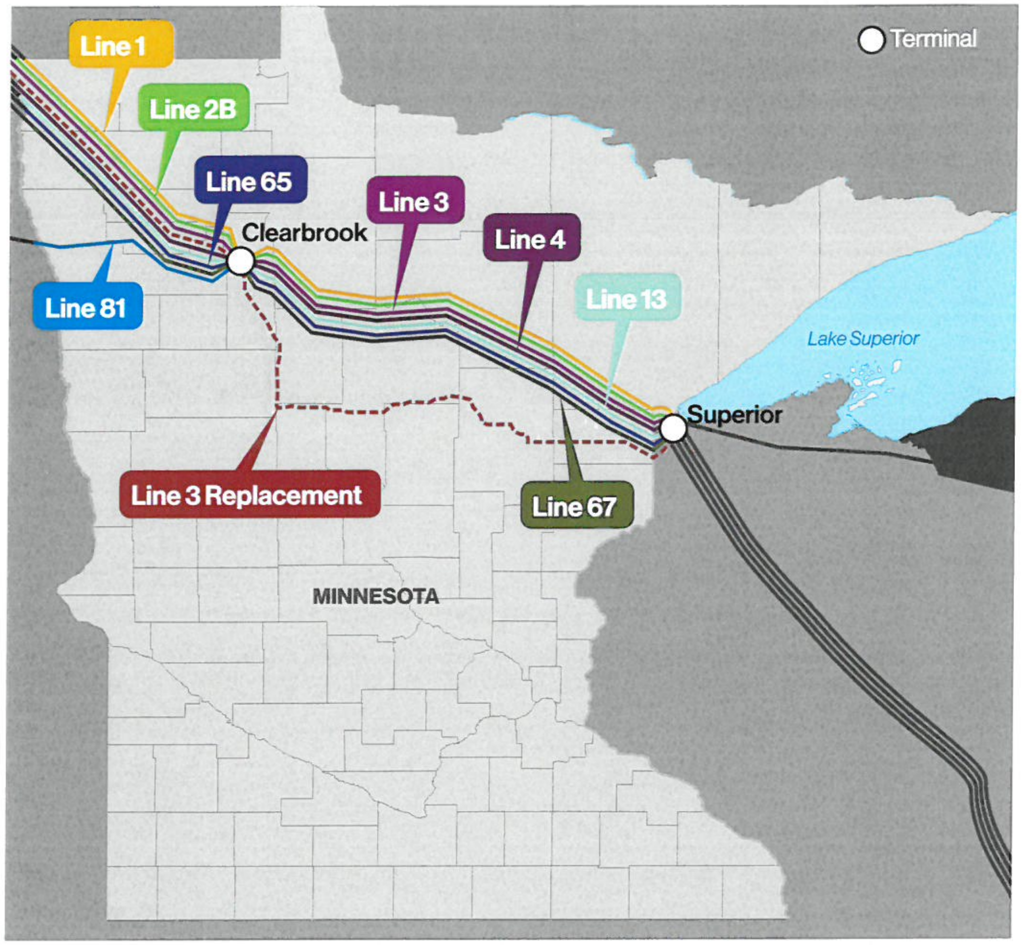
Line 13
A 1,588-mile pipeline carrying diluent from Manhattan, Ill. to Edmonton, Alberta.

Line 65**
A 313-mile pipeline carrying a variety of crude oil from Cromer, Manitoba to Enbridge's Clearbook terminal in Clearbook, Minn. where it connects connects with Minnesota Pipe Line System.

Line 67**
A 999-mile pipeline carrying heavy crude from Hardisty, Alberta to Superior, Wis.

Line 81*
A 283-mile pipeline carrying light Bakken crude oil from Minot, N.D. to Clearbrook, Minn.

Line 3 Replacement**
A proposed replacement of 1,031 miles of pipeline from Hardisty, Alberta to Superior, Wis. which will carry a variety of crude oil.



Current Operations	Line 1	Line 2B	Line 3	Line 4
CAPACITY: (Thousands of barrels per day)	237	442	390	796
PIPE SIZE:	18/20 inch	24/26 inch	34 inch	36/48 inch
CONSTRUCTED:	1950	1957	1968	Early 1970s

Current Operations	Line 13	Line 65	Line 67	Line 81
CAPACITY: (Thousands of barrels per day)	180	186	800	210
PIPE SIZE:	20 inch	20 inch	36 inch	16 inch
CONSTRUCTED:	2010	2010	2009	1962

Proposed Project	Line 3 Replacement
CAPACITY: (Thousands of barrels per day)	760
PIPE SIZE:	36 inch
IN SERVICE:	Early 2019***

Owned by North Dakota Pipeline Company LLC, which is operated by Enbridge.

*** Deliver crude oil to Minnesota refineries - Enbridge meets 80 percent of refining demand in Minnesota*

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Report To Congress On Implementing And Enforcing The Underground Storage Tank Program In Indian Country

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Report to Congress on Implementing and Enforcing the Underground Storage Tank Program in Indian Country

August 2007

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
Washington, DC
www.epa.gov/oust

An UST-LUST Virtual Classroom is also available for tribal tank inspectors and environmental professionals, as well as others interested in learning about USTs. Launched by EPA in 2005, the virtual classroom provides free Internet-accessible introductory level courses and currently consists of two modules: an *Introduction to the UST Program* and *Basic UST Inspector Training.* The virtual classroom can be accessed 24 hours a day on EPA's National Enforcement Training Institute website and on the New England Interstate Water Pollution Control Commission website.[4]

Training is also provided to tribal environmental professionals, UST owners and operators by tribal consortia through EPA grants. The Inter-Tribal Environmental Council (ITEC) has one of the longest running working relationships with EPA on UST issues and offered the first UST owner/operator training through an EPA grant in 2000. To date, over 260 individuals have participated in the training and ITEC continues to provide about six Indian country owner/operator trainings a year.

ITCA training with the Three Affiliated Tribes (North Dakota)

In addition, since October 2001, EPA has been working with the Inter Tribal Council of Arizona (ITCA) to provide additional training to improve the UST program in Indian country. ITCA provides compliance training to tribal environmental professionals on UST regulations, UST installations, and UST inspection protocols. ITCA conducts approximately 20 tribal training sessions every year throughout the U.S. Over 150 tribal environmental professionals have been trained by ITCA to conduct UST inspections and numerous owners and operators have also received basic UST operation and maintenance training.

COMPLIANCE ENFORCEMENT

As the implementing authority, EPA enforces the UST program requirements in Indian country. The most prevalent violations that take place include failure to provide adequate leak detection, failure to provide adequate corrosion protection, failure to provide adequate financial assurance, and failure to perform annual line tightness tests.[5] Enforcement actions, such as field citations, were taken at approximately 35 sites in Indian country in FY 2006.[6]

EPA is committed to working with tribes to ensure that USTs in Indian country are in compliance and providing technical support and assistance to enable compliance. The 1984 "EPA Policy for the Administration of Environmental Programs on Indian Reservations", indicates that EPA should consider taking a civil enforcement action when it determines that (1) a significant threat to human health or the environment exists, (2) such action would reasonably be expected to achieve results in a timely

[4] See http://www.epa.gov/OUST/virtual.htm, *or* http://www.neiwpcc.org/oust1.swf

[5] ***Source:*** *EPA Regional inspection data*

[6] ***Source:*** *EPA Regional End-of-Year FY 2006 data*

Leech Lake Area Summer Visitor Profile:
A focus on interest in culture and nature based experiences

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December 2004

ACKNOWLEDGEMENTS

The University of Minnesota Tourism Center and the Minnesota American Indian Chamber of Commerce would like to acknowledge the following:

Explore Minnesota Tourism, Leech Lake Band of Ojibwe, Leech Lake Area Chamber of Commerce, Cass Lake Chamber of Commerce, Leech Lake Tourism Bureau, and the welcoming communities in the Leech Lake area, particularly the business owners who granted permission for data collection at their establishments.

EXECUTIVE SUMMARY

According to the Travel Industry of America (TIA), a total of 24.5 million U.S. and international travelers visit Minnesota annually (Minnesota Department of Employment and Economic Development 2002). Most of those are pleasure travelers (87%) and, besides the metropolitan area, other state regions realize a rather equal share of the travel market. Thus it is critical to identify visitor's regional variation to maintain and enhance the market share, particularly given the economic importance of tourism to rural areas.

An attractive and emerging travel market are those engaged in nature-based or cultural and heritage based (Hargrove 2004; Hollinshead 1996; Luzar, Diagne, Gan, and Henning 1998; Nicholls, Vogt, and Jun 2004; TIA 2003). Based on national data, a total of 118.1 million U.S. adults participated in cultural or heritage tourism in 2002 (TIA 2003). Additionally, over three quarters (81%) of US adults took at least one trip greater than fifty miles that included at least one cultural activity or event. As an emerging market, available research is site specific and offers a limited understanding of the interest across a broader market (McIntosh 2004). Thus, the goal of this study was to profile an existing tourism market in a particular region, to assess their level of interest in cultural and nature based tourism opportunities. In particular, American Indian cultural tourism opportunities were of interest.

PURPOSE

The purpose of this project was to understand visitors to the Leech Lake area and their specific interests in culture and nature-based experiences. Specific objectives were to:

1) profile existing tourists in the Leech Lake area,
2) identify travel characteristics and expenditures in the Leech Lake area,
3) assess interest in nature-based and culture-based tourism among existing tourist base,
4) measure tourists previous engagement in culture-based tourism, and
5) provide insight into culture-based tourism development opportunities.

METHODS

An onsite questionnaire was administered Leech Lake area tourists in summer 2004. The methods for questionnaire administration are presented in the following sections: study setting, questionnaire, approach, response rate, and analysis.

Study Setting

The Minnesota Leech Lake Band of Ojibwe reservation boundary, located in North Central Minnesota, delimited the study area. Among these 602,889 acres, of which approximately 21,000 are tribally owned, a number of tourist attractions are housed and subsequently, tourism is a dominant economic contributor in the area (Crowley 2003). Historically, the destination area that includes over 200 lakes and the Chippewa National Forest has attracted visitors interested in fishing, boating, hiking, camping, and biking. Several communities provide services, shopping, entertainment, and accommodations for the tourist base.

Questionnaire

The University of Minnesota Tourism Center, in conjunction with the Minnesota American Indian Chamber of Commerce, Leech Lake Band of Ojibwe, and Explore Minnesota Tourism, developed a one-page questionnaire for on-site administration. The questionnaire focused on 1) travel characteristics in the Leech Lake area, 2) travel motivations, 3) interest in several cultural and nature based activities, 4) cultural tourism participation, 5) information sources used to plan the trip, and 6) demographics.

Approach

A comprehensive list of potential survey sites was identified with the assistance of various chambers: Leech Lake Area Chamber of Commerce, Leech Lake Tourism Bureau, and Cass Lake Chamber of Commerce. However, access to casinos and the National Forest visitor was not possible. A data collection schedule was designed to reach a diverse cross section of tourists, thus survey sites, times, and days were varied. Data were collected on-site for 30 days, across four periods between Memorial Day and Labor Day, 2004. Potential participants who self-identified as a tourist, and were willing to participate were provided a questionnaire.

Response Rate

A total of 769 parties were contacted, of which 544 identified themselves as tourist parties (71%). Among those tourists, a total of 506 agreed to participate (93%) and one questionnaire per household was administered.

Analysis

The completed questionnaires were entered, cleaned and checked for singularity and multi-collinearity in SPSS version 12.0. Extreme outliers were windsorized to bring highly skewed variables into usable ranges. Descriptive analysis provided means, standard deviations, and frequencies to describe the sample and provide information on variables of interest. K-means cluster analysis identified groupings by interest in culture-based tourism experiences. Analysis of variance (ANOVA) tested differences among respondents according to travel characteristics and previous cultural/historic travel. Chi-square analysis identified differences among groups when appropriate.

RESULTS

Demographics: Leech Lake area visitor respondents were mature, Anglo and possessed high educational and income status. Respondents ranged in age from eighteen to 84, with a mean age of 46.6 years. Survey respondents were primarily female (62.3 %), Caucasian (97.0 %), highly educated (40.7 % college degree, 17.1 % advanced degree), and reported an annual income greater than $75,000 (54.9 %). Most frequently, respondents indicated either their household composition consisted of a couple with children under eighteen (49.6 %) or a couple with grown children (32.3 %).

Primary destination and reason for travel: Over half (51.7 %) of respondents indicated Leech Lake as their primary trip destination and an additional ten percent respondents indicated the city of Walker, located on the shores of Leech Lake, as their primary destination. The second most frequently cited destination among respondents was Cass Lake, (19.0 %). Similar to statewide travel data (TIA TravelScope 2002), a majority (81.0 %) of respondents cited their primary reason for travel was pleasure or recreation. Over half of the recreational visitors indicated their primary recreation activity was fishing (59.2 %), followed by visiting friends and relatives (34.3 %).

Important experience attributes: Respondents rated the importance of several experience attribute statements. The most highly rated attributes (where 5 equals very important) were "to do something with the family" (M=4.5), "to get away from the usual demands of life" (M=4.4), "to enjoy the scenery" (M=4.3), and "to experience natural quiet" (M=4.1). Attributes rated the least important were "to learn more about the local culture" (M=2.7) and "to meet new people" (M=2.7).

Travel Characteristics: Respondents indicated a long visitation history coupled with frequent visitation in the area. A great majority of respondents (87.3%) had previously visited the area and many of those had a long history of visiting the area: respondents, on average, had been visiting the Leech Lake area for 15.3 years. The average number of trips respondents had taken to the Leech Lake area in the previous year was 2.7. Over one third (35.2 %) had visited the area more than once in the previous year.

On average, respondents spent a total of 8.3 nights away from home. Of those nights, an average of 6.7 were spent in the Leech Lake area. A majority of respondents (74.8 %) spent between three and eight days in the Leech Lake area. Nearly ten percent (9.9 %) spent one or two days in the Leech Lake area.

Most frequently, respondents to this questionnaire stayed in resorts (63.7 %). The second most frequently cited accommodation type were motels or hotels, where slightly less than one in ten (9.1 %) respondents indicated so.

Respondents indicated relatively large travel party size, as shown by the average travel party (M=8.6 people). Respondents' party size ranged from one to 48 people. However, over one third (41.9 %) indicated traveling with four or fewer people.

Average expenditures, in the previous 24-hour time period, were calculated based on respondents who reported expenditures in a particular category. Lodging was the top expenditure, where respondents reported spending an average of $192.12. Among those who indicated expenditures at a casino, the average spent was $65.30. Shopping was also a top expenditure category among respondents, where respondents indicated spending an average of $61.01. Very few respondents indicated expenditures in the categories of guides/outfitting or cultural arts.

Information sources for trip planning: Of the twelve information sources provided, the most frequently noted source was the Internet (52.7 %). Other top sources of information included previous visit (40.9 %) and recommendations from friends or relatives (31.9 %).

Cultural tourism participation: Similar to TIA findings (2003), a majority of respondents in the Leech Lake area had engaged in some type of historic or cultural travel in the preceding year. Over three quarters (78.7 %) of respondents indicated participation in at least one of the fifteen TIA historical/cultural activity categories. Nearly three quarters (73.3 %) of respondents engaged in culture-based activities or events, while slightly over half (54.7 %) engaged in historic related activities. Leech Lake area respondents attendance at art museums and antique establishments were among the highest cultural tourism activities cited of the 15 choices.

Nature-based tourism and cultural tourism interest: Among the nature-based tourist experiences queried, interest in fishing had the highest rating ($\underline{M}$=4.0). Respondents indicated moderate interest in wildlife viewing and nature photography ($\underline{M}$=3.7 and $\underline{M}$=3.2, respectively). Specific activities, such as fish hatchery tours, wild rice processing tours, and Winnie Ponds Fish and Wildlife Management self-guided tours garnered lower interest levels among respondents. On average, respondents were least interested in hunting ($\underline{M}$=2.6).

Interest in several existent or potential culture-based tourist experiences was queried. On average, respondents indicated low to moderate level of interest across all six experiences. The items that had the highest percentage of interested respondents were traditional Native American dance performances, tribal gift shops, and Native American cultural heritage history center.

Differences among respondents: Respondents were segmented to better understand their patterns and needs. The two segmentation methods used were engagement in cultural/historic travel and interest in culture-based tourism. When segmented by level of engagement in cultural/historic travel, significant differences in interest emerged, not surprisingly. Specifically, as the level of previous engagement in cultural or historic tourism increased, the level of interest in cultural-based tourism experiences increased.

When segmented by cluster analysis, four groups emerged: low, passive moderates, active moderates, and high interest**.** As their name suggests, interest level increased within the clusters and significantly differentiated them. Information and travel patterns were also differentiated within the clusters. Passive and high interest groups used local and state tourism information significantly more than the other groups. High interest groups had smaller travel parties and longer area visitation histories than the other groups.

DISCUSSION

Prior to any discussion, we acknowledge that successful tourism development depends on accurate community and tribal assessments of attitudes toward that development. While it remains important to understand the desires and interests of tourists, it is imperative to also determine what aspects of a culture (i.e. practices, traditions, and beliefs) can be shared, transferred, or presented. This type of information can and should be obtained from the tribal members themselves.

Respondents: Leech Lake area visitor respondents were mature, Anglo and possessed high educational and income status. These visitors reflect the nature and culture based tourism market that, compared to other travelers, is older, more likely to be retired, more affluent, and more educated (TIA 2003).

In terms of stay and expenditures, Leech Lake area respondents indicated a longer stay (6.7 nights vs 3 nights, respectively; Minnesota Department of Employment and Economic Development 2002) than the typical Minnesota traveler. This is, in a large part, attributed to the proportion of respondents staying in resorts. Recent research on the resort market indicates that the baby boomers will remain the key component (Goodman 1994). However, this ‘boomer’ also has specific desires for novelty (National Travel Monitor 1998), family accommodations (Chon and Singh 1995), as well as flexible resort opportunities: educational, cultural, or sport experiences (Cato and Knustler 1988). Thus, the boomers are appealing base for cultural tourism development.

Information sources for trip planning: Following national and state trends, travel planning continues to be increasingly reliant on the Internet. Leech Lake area visitors are online and mirror the use of other travelers in their use of the Internet to plan and book travel. Subsequently, ensuring current and interesting web pages represent the area is critical. Further exploration of exactly what resources visitors are using on the Internet would be helpful for advertising as well as to clarify if, in fact, visitors are using information on the Internet provided by the local tourism organizations. In addition to the Internet, previous experiences and word of mouth via friends and families remain important information sources for trip planning.

Fortunately, the information sources most used by cultural travelers are the same as those used by the current Leech Lake visitor base: Internet (TIA 2003), word of mouth (TIA 2003; Prideaux and Kininmont 1999), and friends and family (Prideaux and Kininmont 1999). However, as both passive and interested cultural/historic travelers used local and state information sources more than the other cluster groups, accurate and interesting information at these venues is encouraged.

Engagement and interest in nature based tourism: While the majority of pleasure travelers were there to fish, another nature based activity of interest among them is wildlife viewing. Specific to wildlife viewing, Minnesota ranked second in participation behind Vermont in the 2000 national survey of wildlife related recreation (USFWS 2002). Beyond attention to the wildlife viewing experience itself, a combination of additional nature based activities and cultural/historic opportunities are likely to enhance experiences and extend wildlife viewing trips and vice versa. Therefore, marketing and partnering with local area attractions is suggested.

Given the majority of current recreational visitors are there to fish, further consideration of a fish hatchery tour seems logical. Inclusion of both historical and cultural elements within the tour can emphasize the educational aspect of the tour and subsequently, may qualify for grant monies for development.

Engagement and interest in culture based tourism: Like the traveling U.S. population, Leech Lake area visitors have a range of experiences in recent cultural/historic event participation while traveling. When asked to consider interest for such opportunities in the Leech Lake area, summer 2004 tourists were largely unsure of their interest. Similar to past research (Moscardo and Pearce 1999), four levels of interest in cultural tourism emerged. Initial product and program development should focus in on the twenty percent of respondents who expressed interest in cultural-based tourism opportunities.

Based on respondent interest and previous cultural travel engagement, developing attractions and/or programs based in American Indian art and related product seems prudent. Most cultural travelers participate in more than one cultural activity, attraction, or destination during their trip (Zeppel 2002) and therefore, it is important to have a package of opportunities to consider. Interactive educational opportunities with observation available are an obvious draw. Further, the broad interest in gift shops among all respondents to this questionnaire, coupled with their spending on gifts, suggests that a gift shop should definitely be apart of whatever offering emerges. Given the extensive use history among respondents, learning more about their attachment to the Leech Lake area may assist with program and product development. Framing some of the programming and tourism products using a common place that both the tribe and visitors care about may prove a useful marketing strategy as well as a way to ease the stress of cultural tourism on the tribe.

FUTURE RESEARCH

This project was the first attempt to investigate the level of interest in culture-based tourism, particularly American Indian tourism opportunities, in Minnesota. Given that it is a snapshot view of a particular tribal area within the state, additional information could enhance statewide cultural tourism efforts. Further, monitoring level of interest in various tourism experience opportunities is suggested.

Just as it is important to understand the current tourism market base, it is equally important to assess community and tribal support for tourism development. This could be achieved through in-depth interviews among key players in the community, or alternatively conduct a tourism impact assessment, using the tourism impact assessment scale developed by Lankford (1994).

The uncertainty of the current market about future culture tourism opportunities suggests product expectations and preferences are not yet set. By obtaining detailed knowledge of consumer expectations and preferences, the tribe can choose among the potential projects those that celebrate the culture, while protecting those that may impede on its sacredness.

As nature and cultural tourism opportunities are considered, identifying their important elements and how the tribe performs on providing those elements will be critical. Therefore, importance-performance analysis is suggested.

Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain

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Methyl mercury is a developmental neurotoxicant. Exposure results principally from consumption by pregnant women of seafood contaminated by mercury from anthropogenic (70%) and natural (30%) sources. Throughout the 1990s, the U.S. Environmental Protection Agency (EPA) made steady progress in reducing mercury emissions from anthropogenic sources, especially from power plants, which account for 41% of anthropogenic emissions. However, the U.S. EPA recently proposed to slow this progress, citing high costs of pollution abatement. To put into perspective the costs of controlling emissions from American power plants, we have estimated the economic costs of methyl mercury toxicity attributable to mercury from these plants. We used an environmentally attributable fraction model and limited our analysis to the neurodevelopmental impacts—specifically loss of intelligence. Using national blood mercury prevalence data from the Centers for Disease Control and Prevention, we found that between 316,588 and 637,233 children each year have cord blood mercury levels > 5.8 µg/L, a level associated with loss of IQ. The resulting loss of intelligence causes diminished economic productivity that persists over the entire lifetime of these children. This lost productivity is the major cost of methyl mercury toxicity, and it amounts to $8.7 billion annually (range, $2.2–43.8 billion; all costs are in 2000 US$). Of this total, $1.3 billion (range, $0.1–6.5 billion) each year is attributable to mercury emissions from American power plants. This significant toll threatens the economic health and security of the United States and should be considered in the debate on mercury pollution controls. ***Key words:*** **children's health, cognitive development, cord blood, electrical generation facilities, environmentally attributable fraction, fetal exposure, lost economic productivity, mercury, methyl mercury, power plants. *Environ Health Perspect* 113:590–596 (2005). doi:10.1289/ehp.7743 available via *http://dx.doi.org/* [Online 28 February 2005]**

Mercury is a ubiquitous environmental toxicant (Goldman et al. 2001). It exists in three forms, each of which possesses different bioavailability and toxicity: the metallic element, inorganic salts, and organic compounds (methyl mercury, ethyl mercury, and phenyl mercury) (Franzblau 1994). Although volcanoes and other natural sources release some elemental mercury to the environment, anthropogenic emissions from coal-fired electric power generation facilities, chloralkali production, waste incineration, and other industrial activities now account for approximately 70% of the 5,500 metric tons of mercury that are released into the earth's atmosphere each year [United Nations Environmental Programme (UNEP) 2002]. Elemental mercury is readily aerosolized because of its low boiling point, and once airborne it can travel long distances to eventually deposit into soil and water. In the sediments of rivers, lakes, and the ocean, metallic mercury is transformed within microorganisms into methyl mercury (Guimaraes et al. 2000). This methyl mercury biomagnifies in the marine food chain to reach very high concentrations in predatory fish such as swordfish, tuna, king mackerel, and shark (Dietz et al. 2000; Gilmour and Riedel 2000; Mason et al. 1995; Neumann and Ward 1999). Consumption of contaminated fish is the major route of human exposure to methyl mercury.

The toxicity of methyl mercury to the developing brain was first recognized in the 1950s in Minamata, Japan, where consumption of fish with high concentrations of methyl mercury by pregnant women resulted in at least 30 cases of cerebral palsy in children; exposed women were affected minimally if at all (Harada 1968). A similar episode followed in 1972 in Iraq when the use of a methyl mercury fungicide led to poisoning in thousands of people (Bakir et al. 1973); again, infants and children were most profoundly affected (Amin-Zaki et al. 1974, 1979). The vulnerability of the developing brain to methyl mercury reflects the ability of lipophilic methyl mercury to cross the placenta and concentrate in the central nervous system (Campbell et al. 1992). Moreover, the blood–brain barrier is not fully developed until after the first year of life, and methyl mercury can cross this incomplete barrier (Rodier 1995).

Three recent, large-scale prospective epidemiologic studies have examined children who experienced methyl mercury exposures *in utero* at concentrations relevant to current U.S. exposure levels. The first of these studies, a cohort in New Zealand, found a 3-point decrement in the Wechsler Intelligence Scale-Revised (WISC-R) full-scale IQ among children born to women with maternal hair mercury concentrations > 6 µg/g (Kjellstrom et al. 1986, 1989). A second study in the Seychelles Islands in the Indian Ocean found only one adverse association with maternal hair mercury concentration among 48 neurodevelopmental end points examined (prolonged time to complete a grooved pegboard test with the nonpreferred hand) (Myers et al. 2003). However, the grooved pegboard test was one of the few neurobehavioral instruments in the Seychelles study not subject to the vagaries of translation that can degrade the validity of culture-bound tests of higher cognitive function when they are applied in developing nations (Landrigan and Goldman 2003). A third prospective study in the Faroe Islands, a component of Denmark inhabited by a Scandinavian population in the North Atlantic, has followed a cohort of children for 14 years and collected data on 17 neurodevelopmental end points, as well as on the impact of methyl mercury on cardiovascular function. The Faroes researchers found significant dose-related, adverse associations between prenatal mercury exposure and performance on a wide range of memory, attention, language, and visual-spatial perception tests (Grandjean et al. 1997). The significance of these associations remained evident when

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We are grateful for the helpful advice of P. Grandjean, E. Budtz-Jorgensen, D. Laraque, P. Leigh, and J. Palfrey as well as to D.P. Rice and W. Max for their assistance with lifetime earnings estimates.

This research was supported by a grant from the National Institute of Environmental Health Sciences through the Superfund Basic Research Program (PT42ES07384) to Mount Sinai School of Medicine, and by the Jenifer Altman Foundation, Physicians for Social Responsibility, and the Rena Shulsky Foundation.

The authors declare they have no competing financial interests.

Received 10 November 2004; accepted 28 February 2005.

blood levels of polychlorinated biphenyls, which are known developmental neurotoxicants (Jacobson and Jacobson 1996), were included in the analysis (Budtz-Jorgensen et al. 2002; Steuerwald et al. 2000). Methyl mercury exposure was also associated with decreased sympathetic- and parasympathetic-mediated modulation of heart rate variability (Grandjean et al. 2004) and with persistent delays in peaks I–III brainstem evoked potentials (Murata et al. 2004).

An assessment of these three prospective studies by the National Academy of Sciences (NAS) (National Research Council 2000) concluded that there is strong evidence for the fetal neurotoxicity of methyl mercury, even at low concentrations of exposure. Moreover, the NAS opined that the most credible of the three prospective epidemiologic studies was the Faroe Islands investigation. In recommending a procedure for setting a reference dose for a methyl mercury standard, the NAS chose to use a linear model to represent the relationship between mercury exposure and neurodevelopmental outcomes, and based this model on the Faroe Islands data. The NAS found that the cord blood methyl mercury concentration was the most sensitive biomarker of exposure *in utero* and correlated best with neurobehavioral outcomes. The NAS was not deterred by the apparently negative findings of the Seychelles Islands study, which it noted was based on a smaller cohort than the Faroe Islands investigation and had only 50% statistical power to detect the effects observed in the Faroes (National Research Council 2000).

Since January 2003, the issue of early life exposure to methyl mercury has become the topic of intense debate after the U.S. Environmental Protection Agency (EPA) announced a proposal to reverse strict controls on emissions of mercury from coal-fired power plants. This proposed "Clear Skies Act" would slow recent progress in controlling mercury emission rates from electric generation facilities and would allow these releases to remain as high as 26 tons/year through 2010 (U.S. EPA 2004a). By contrast, existing protections under the Clean Air Act will limit mercury emissions from coal-fired power plants to 5 tons/year by 2008 (U.S. EPA 2004b). The U.S. EPA's technical analyses in support of "Clear Skies" failed to incorporate or quantify consideration of the health impacts resulting from increased mercury emissions (U.S. EPA 2004c). After legislative momentum for this proposal faded, the U.S. EPA proposed an almost identical Utility Mercury Reductions Rule, which again failed to examine impacts on health. The U.S. EPA issued a final rule on 15 March 2005 (U.S. EPA 2005).

To assess the costs that may result from exposure of the developing brain to methyl mercury, we estimated the economic impact of anthropogenic methyl mercury exposure in the 2000 U.S. birth cohort. We calculated the fraction of this cost that could be attributed to mercury emitted by American electric power generation facilities.

Materials and Methods

Environmentally attributable fraction model. To assess the disease burden and the costs due to methyl mercury exposure, we used an environmentally attributable fraction (EAF) model. The EAF approach was developed by the Institute of Medicine (IOM) to assess the "fractional contribution" of the environment to causation of illness in the United States (IOM 1981), and it has been used to assess the costs of environmental and occupational disease (Fahs et al. 1989; Leigh et al. 1997). It was used recently to estimate the environmentally attributable costs of lead poisoning, asthma, pediatric cancer, and neurodevelopmental disabilities in American children (Landrigan et al. 2002). The EAF is defined by Smith et al. (1999) as "the percentage of a particular disease category that would be eliminated if environmental risk factors were reduced to their lowest feasible concentrations." The EAF is a composite value and is the product of the prevalence of a risk factor multiplied by the relative risk of disease associated with that risk factor. Its calculation is useful in developing strategies for resource allocation and prioritization in public health. The general model developed by the IOM and used in the present analysis is the following:

$$\text{Costs} = \text{disease rate} \times \text{EAF} \times \text{population size} \times \text{cost per case}$$

"Cost per case" refers to discounted lifetime expenditures attributable to a particular disease, including direct costs of health care, costs of rehabilitation, and lost productivity. "Disease rate" and "population size" refer, respectively, to the incidence or prevalence of a disease and the size of the population at risk.

In applying the EAF model, we first reviewed the adverse effects of methyl mercury exposure. We then estimated the costs of those effects and subsequently applied a further fraction to parse out the cost of anthropogenic methyl mercury exposure resulting from emissions of American electrical generation facilities.

Toxic effects of methyl mercury exposure. The NAS found neurodevelopmental effects in the children of women who had consumed fish and seafood during pregnancy to be the most important and best-studied end point for methyl mercury toxicity. Although the NAS identified other potentially significant toxicities resulting from methyl mercury exposure, such as nephrotoxicity and carcinogenicity, those effects were less well characterized (National Research Council 2000). We therefore limited our analysis to the neurodevelopmental impact of methyl mercury toxicity.

There is no evidence to date validating the existence of a threshold blood mercury concentration below which adverse effects on cognition are not seen. The U.S. EPA has, however, set a benchmark dose level (BMDL) for cord blood mercury dose concentration of 58 µg/L. This level that corresponds to the lower limit of the 95% confidence interval for the concentration at which there is a doubling in the Faroes study in the prevalence of test scores (5–10%) in the clinically subnormal range for the Boston Naming Test (Rice et al. 2003). It is important to note that this is not a concentration below which no observed adverse effects were found. The Faroes and New Zealand cohorts both support the conclusion that developmental effects become apparent at levels of approximately 1 ppm mercury in hair, or 5.8 µg/L in cord blood (Grandjean et al. 1997; Kjellstrom et al. 1986, 1989). The Faroes study also found that effects on delayed brainstem auditory responses occurred at much lower exposure concentrations (Murata et al. 2004). In its report, the NAS concluded that the likelihood of subnormal scores on neurodevelopmental tests after *in utero* exposure to methyl mercury increased as cord blood concentrations increased from levels as low as 5 µg/L to the BMDL of 58 µg/L (National Research Council 2000). In light of those findings, we decided in this analysis to apply a no adverse effect level of 5.8 µg/L, the lowest level at which adverse neurodevelopmental effects were demonstrated in the cohort studies.

Recent data suggest that the cord blood mercury concentration may on average be 70% higher than the maternal blood mercury concentration (Stern and Smith 2003), and a recent analysis suggests that a modification of the U.S. EPA reference dose for methyl mercury be made to reflect a cord blood:maternal blood ratio that is > 1 (Stern 2005). If the developmental effects of mercury exposure do, in fact, begin at 5.8 µg/L in cord blood, as suggested by the Faroes (Grandjean et al. 1997) and New Zealand (Kjellstrom et al. 1986, 1989) data and by the NAS report (National Research Council 2000), then effects would occur in children born to women of childbearing age with blood mercury concentrations ≥ 3.41 (ratio, 5.8:1.7) µg/L. National population data from the 1999–2000 National Health and Nutrition Examination Survey (NHANES) found that 15.7% of American women of childbearing age have total blood mercury concentrations ≥ 3.5 µg/L (Mahaffey et al. 2004).

To compute IQ decrements in infants that have resulted from these elevated maternal mercury exposures, we used published data on percentages of women of childbearing age with mercury concentrations ≥ 3.5, 4.84, 5.8, 7.13, and 15.0 μg/L. We assumed conservatively that all mercury concentrations within each of the segments of the distribution were at the lower bound of the range. We assumed that the probability of giving birth to a child did not correlate with mercury level in a woman of childbearing age. In our base case analysis, we calculated economic costs assuming that children born to women with mercury concentrations 3.5–4.84 μg/L suffer no loss in cognition, and that successive portions of the birth cohort experience loss of cognition associated with cord blood levels of 8.2, 9.9, 12.1, and 25.5 μg/L, respectively.

Recently, the Faroes researchers reviewed their cohort data and found fetal blood mercury concentrations to be only 30% higher than maternal blood concentrations (Budtz-Jorgensen et al. 2004). In light of these findings and to avoid overestimation of the magnitude of impacts, we chose not to include children born to mothers with blood mercury concentrations between 3.5 and 4.84 μg/L in our base case analysis.

To assess the impact on our findings of a range of various possible ratios between maternal and cord blood mercury concentrations, we conducted a sensitivity analysis. In this analysis, we set as a lower bound for our estimate the costs to children with estimated cord blood concentrations ≥ 5.8 μg/L (assuming a cord:maternal blood ratio of 1) and assumed no IQ impact < 4.84 μg/L (assuming a cord:maternal blood ratio of 1.19). This estimate assumed no loss of cognition to children born to women with mercury concentration < 5.8 μg/L and assumed that subsequent portions of the birth cohort experienced cord blood mercury concentrations of 5.8, 7.13, and 15 μg/L, respectively. To estimate economic costs in this scenario, we calculated no costs for children with blood mercury concentrations < 4.84 μg/L. We calculated costs resulting from an incremental increase in blood mercury concentration from 4.84 to 5.8 μg/L in the percentage of the population with blood mercury levels between 5.8 and 7.13 μg/L, and added those costs to the costs resulting from increases from 4.84 to 7.13 μg/L and 4.84 to 15 μg/L in the percentages of the population with concentrations between 7.13 and 15 μg/L and > 15 μg/L, respectively. The result of this calculation is expressed in our analysis as a lower bound for the true economic cost of methyl mercury toxicity to the developing brain.

Impact of methyl mercury exposure on IQ. The Faroes study found that a doubling of mercury concentration was associated with adverse impacts on neurodevelopmental tests ranging from 5.69–15.93% of a standard deviation (Grandjean et al. 1999). Assuming that IQ is normally distributed with a standard deviation of 15 points, a doubling of mercury concentration would be associated with a decrement ranging from 0.85 to 2.4 IQ points. The Faroes researchers used a structural equation analysis to produce estimates of impact of methyl mercury on verbal and motor function at 7 years of age and found an association between a doubling of blood mercury and loss of 9.74% of a standard deviation on motor function and of 10.45% of a standard deviation on verbal function (Budtz-Jorgensen et al. 2002). This analysis suggests that a doubling in mercury concentration produces a decrement of approximately 10% of a standard deviation, or 1.5 IQ points. In the New Zealand study (Kjellstrom et al. 1986, 1989), the average WISC-R full-scale IQ for the study population (n = 237) was 93. In the group with maternal hair mercury > 6 μg/g (~ 4-fold higher than in the study population, n = 61), the average was 90 (Kjellstrom et al. 1989). This finding further supports our use of a loss of 1.5 IQ points for each doubling in our base case analysis. Confounders such as polychlorinated biphenyls did not cause significant confounding of the data in the Faroe Islands study (Budtz-Jorgensen et al. 2002; Steuerwald et al. 2000). As a conservative measure, we nonetheless chose to set as outer bounds for the impact on intelligence of methyl mercury exposure a range of IQ decrements from 0.85 to 2.4 IQ points per doubling, as described by the Faroes researchers (Jorgensen et al. 2004). In applying the EAF methodology, we assume that the relationship between cord blood mercury and IQ is relatively linear over the range of exposures studied (> 5.8 μg/L).

In our sensitivity analysis, we used the same linear dose–response model that was selected by the National Research Council in setting a reference dose for mercury exposure (National Research Council 2000). The Faroes researchers found that, for those children whose mothers had hair mercury concentrations < 10 μg/g, a 1-μg/L increase of cord blood mercury concentration was associated with adverse impacts on neurodevelopmental tests ranging from 3.95 to 8.33% of a standard deviation, or 0.59–1.24 IQ points (average = 0.93 IQ points) (Jorgensen et al. 2004). We also varied the cord:maternal blood mercury ratio from 1 to 1.7 in calculating IQ impact from the linear model as part of our sensitivity analysis. As an upper bound to our cost estimate using the logarithmic model, we calculated the economic cost assuming that children born to women with mercury concentrations 3.5–4.84 μg/L suffer no loss in cognition and that successive portions of the birth cohort experience losses of cognition of 1.21, 1.84, 2.55, and 5.13 IQ points, respectively. The lower-bound estimate assumed that children born to women with mercury concentrations 4.84–5.8 μg/L suffer no loss in cognition and that successive portions of the birth cohort experience losses of cognition of 0.22, 0.48, and 1.39 IQ points.

As an upper bound to our cost estimate using the linear model, we calculated the economic cost assuming that children born to women with mercury concentrations 3.5–4.84 μg/L suffer no loss in cognition and that successive portions of the birth cohort experience losses of cognition of 3.01, 5.04, 7.84, and 24.43 IQ points, respectively. The lower-bound estimate assumed that children born to women with mercury concentrations 4.84–5.8 μg/L suffer no loss in cognition and that successive portions of the birth cohort experience losses of cognition of 0.56, 1.35, and 5.99 IQ points.

Calculation of economic costs of IQ loss. To estimate the costs associated with the cognitive and behavioral consequences of mercury exposure, we relied on an economic forecasting model developed by Schwartz et al. (1985), and we applied this model to NHANES data on prevalence of mercury exposure in women of childbearing age (Schober et al. 2003; Schwartz et al. 1985). In this model, lead concentrations are assumed on the basis of work by Salkever (1995) to produce a dose-related decrement in IQ score. Those decrements in IQ are, in turn, associated with lower wages and diminished lifetime earning power. Salkever used three regression techniques to derive direct and indirect relationships among IQ, schooling, probability of workforce participation, and earnings. He estimated a percentage in lost earnings per IQ point from the percent loss of earnings for each microgram per deciliter increase in blood lead level. Salkever found a 0.473 point decrement in lost lifetime earnings for each microgram per deciliter increase among men and a 0.806 point decrement for each microgram per deciliter increase among women (Salkever 1995). Using Schwartz's (1994) estimate that 0.245 IQ points are lost for each microgram per deciliter increase in blood lead, Salkever (1995) estimated a percentage loss in lifetime earnings per IQ point among men (1.931%) and women (3.225%). We assume that this relationship remains linear across the population range of IQ.

Assuming an annual growth in productivity of 1% and applying a 3% real discount rate, the present value of lifetime expected earnings is $1,032,002 for a boy born in 2000 and $763,468 for a girl born in the same year (Max et al. 2002). The costs of the diminution in this earning power were calculated for the 2000 American birth cohort, using available data on the number of male and female births in 2000 [Centers for Disease Control and Prevention (CDC) 2002a]. We diminished our cost estimate by

0.69%, the infant mortality rate in 2000, to account for those children for whom methyl mercury exposure is unlikely to result in diminished economic productivity (CDC 2002b).

American sources of mercury emission. Mercury emissions result from anthropogenic as well as from natural sources, and we limited our analysis to methyl mercury derived from anthropogenic sources. The UNEP recently estimated that anthropogenic uses account for 70% of the 5,500 tons of mercury released into the earth's atmosphere worldwide (UNEP 2002). Therefore, to limit our analysis to anthropogenic mercury, we applied a 70% factor to convert the cost of lost economic productivity resulting from methyl mercury exposure to the cost attributable to anthropogenic methyl mercury exposure.

We next parsed out the proportion of anthropogenic methyl mercury in fish that arises from American sources and then isolated the subset of that proportion that is emitted by coal-fired electrical generating plants. In 1995, the most recent year for which federal data on the relative deposition of mercury from American and other global sources are available, 158 tons of mercury were emitted to the atmosphere by American anthropogenic sources. Fifty-two (33%) of those 158 tons were deposited in the lower 48 states, whereas the remaining two-thirds were added to the global reservoir (U.S. EPA 2004d). Also in 1995, an additional 35 tons of mercury from the global reservoir were deposited in the United States. Therefore, a total of 87 total tons of mercury were deposited in the United States in that year, of which 60% (52 of 87) were attributable to American anthropogenic sources (U.S. EPA 1996, 1997). This mercury would have been available to bioaccumulate in the marine and aquatic food chains and to enter American freshwater and saltwater fish.

Further complicating our calculations is the fact that not all of the fish sold in America is from American sources. Of the 10.4 billion pounds of edible fish supplied in the United States in 2002, 4.4 billion (42%) are imported from sources outside of the United States (National Marine Fisheries Service 2002). Because U.S. emissions account for 3% of global emissions (UNEP 2002; U.S. EPA 1996), we calculate that the mercury content of imported fish is 2% of American anthropogenic origin: 158 tons of American emissions – 52 tons of American mercury deposited on American soil = 106 tons of American mercury available to contaminate imported fish; 5,500 tons emitted globally – 87 tons deposited on American soil = 5,413 tons of mercury from all sources to contaminate imported fish; 106 tons of mercury available/ 5,413 tons of mercury from all sources = 0.02, or 2% of mercury in imported fish of American origin. In the remaining 58% of fish consumed in the United States, we assume that 60% of the mercury content comes from American anthropogenic sources (U.S. EPA 1996, 1997). We therefore applied a 36% factor (the weighted average of American sources of mercury content in fish, or $0.6 \times 0.58 + 0.02 \times 0.42$) to specify the economic costs of anthropogenic methyl mercury exposure attributable to American sources.

Modeling supported by the Electric Power Resource Institute (EPRI) estimates that 70% of the mercury deposited in the United States comes from foreign sources (Seigneur et al. 2004). This EPRI analysis also finds that U.S. sources are responsible for > 60% of mercury deposition in the Boston–Washington, D.C. corridor. In one of the model's selected receptor areas—Pines Lake, New Jersey—80% of the deposition originated from U.S. sources, showing that regional deposition can be higher than the 60% number we use in this analysis (Seigneur et al. 2004). In our sensitivity analysis, we varied the factor used to convert the economic cost of anthropogenic methyl mercury exposure to the economic cost attributable to American sources from 18% ($0.3 \times 0.58 + 0.02 \times 0.42$, using EPRI's modeling) to 36% (using federal data on mercury deposition) (Seigneur et al. 2004).

In 1999, the most recent year for which data on American mercury emissions are available, 48 (41%) of the 117 tons of mercury emissions from anthropogenic sources in the United States were emitted by electric power generation facilities (U.S. EPA 2003a). To calculate the economic cost of methyl mercury exposure attributable to these facilities, we applied an additional fraction of 41% in our analysis.

Results

Base-case analysis. Each year in the United States, between 316,588 (7.8% of the annual birth cohort) and 637,233 babies are born with cord blood mercury levels > 5.8 μg/L. The lower-bound estimate of 316,588 babies is based on the very conservative assumption that maternal and cord blood mercury concentrations are equal. But if the cord blood mercury concentration is on average 70% higher than the maternal blood mercury concentration, as suggested by recent research (Stern and Smith 2003), 637,233 babies, or 15.7% of the birth cohort, experience cord blood mercury levels > 5.8 μg/L. Fetal blood mercury levels > 5.8 μg/L are associated with small but significant loss of IQ. This decrement in IQ appears to be permanent and irreversible, and it adversely affects a significant portion of the annual birth cohort's economic productivity over a lifetime.

Using our base-case assumptions (impact for women with total mercury > 4.84 μg/L, cord:maternal mercury ratio = 1.7, IQ impact = 1.5 points per doubling), we calculated costs for the 405,881 children who suffer IQ decrements resulting from fetal methyl mercury exposure. Under these assumptions, 89,293 children suffered a 0.76 decrement in IQ and another 113,647 experienced a 1.15 IQ point decrement. The 5% most highly exposed children in the 2000 birth cohort suffered subclinical losses in IQ in our model ranging from 1.60 to 3.21 points. Although this diminution in intelligence is small in comparison with the loss of cognition that can result from other genetic and environmental processes, the loss resulting from methyl mercury exposure produces a significant reduction in economic productivity over a lifetime. We estimate the aggregate cost of the loss in IQ that results from exposure of American children to methyl mercury of anthropogenic origin to be $8.7 billion (all costs in 2000 US$) annually (Table 1).

Sensitivity analysis. We estimate that the cost of anthropogenic methyl mercury exposure ranges from $2.2 billion (impact only for the 316,588 children born to women with total mercury > 5.8 μg/L, IQ impact = 0.85 points per doubling) to $13.9 billion (impact for the 405,881 women with total mercury > 4.84 μg/L, IQ impact = 2.4 points per doubling). Using the linear dose–response model that was selected by the National Research Council in recommending a reference dose for mercury exposure (a model that predicts an average loss of 0.93 IQ points per 1-μg/L increase in mercury concentration) (Jorgensen et al. 2004; National Research Council 2000), we find that the environmentally attributable cost of methyl mercury exposure is $32.9 billion, assuming a cord:maternal blood mercury ratio of 1.7. Employing a linear model and assuming that the true loss in IQ resulting from a 1-μg/L increase in blood mercury ranges from 0.59 to 1.24 points, we find that the outer bounds of our estimate range from $7.0 billion (impact only for women with total mercury > 5.8 μg/L, IQ impact = 0.59 points per μg/L increase, cord:maternal mercury ratio = 1) to $43.8 billion (impact for women with total mercury > 4.84 μg/L, IQ impact = 1.24 points for each microgram per deciliter increase, cord:maternal mercury ratio = 1.7) (Table 2).

Sources of costs. After applying the 36% fraction to restrict our analysis to American anthropogenic sources, we estimate that the attributable cost of methyl mercury exposure to the developing fetus from American anthropogenic sources is $3.1 billion annually, using the logarithmic model developed by the Faroes researchers (Grandjean et al. 1999; Jorgensen et al. 2004) and assuming a 1.5-point IQ impact for each doubling of methyl mercury exposure (Budtz-Jorgensen et al. 2002). Our sensitivity analysis, in which we also varied the attributable fraction for American sources from 18% (industry data sources) to 36% (federal data sources) (Seigneur et al. 2004; U.S. EPA 1996, 1997), suggests that the true cost of methyl mercury exposure from American emissions ranges from $0.4 to $15.8 billion annually.

To focus specifically on the costs of fetal exposure to mercury released by American coal-fired power plants, we examined the impact of the 41% of U.S. anthropogenic emissions of mercury attributable to these facilities. We estimate that the attributable cost of methyl mercury exposure from American electric generation facilities to the developing fetus is $1.3 billion. Applying our sensitivity analysis in this model, we find that the true cost of methyl mercury exposure from electric generation facilities to the American birth cohort ranges from $0.1 to $6.5 billion/year (Figure 1). Again, the major source of these costs is loss of earnings over a lifetime.

Discussion

The major findings in this analysis are *a*) that exposure to methyl mercury emitted to the atmosphere by American electric generation facilities causes lifelong loss of intelligence in hundreds of thousands of American babies born each year and *b*) that this loss of intelligence exacts a significant economic cost to American society, a cost that amounts to at least hundreds of millions of dollars each year. Moreover, these costs will recur each year with each new birth cohort as long as mercury emissions are not controlled. By contrast, the cost of installing stack filters to control atmospheric mercury emissions is a one-time expense. The high costs of *in utero* exposure to methyl mercury are due principally to the lifelong consequences of irreversible injury to the developing brain. Similar lifelong neurobehavioral consequences have been observed after exposure of the developing brain to other environmental toxicants, including lead (Baghurst et al. 1987; Bellinger 2004; Dietrich et al. 1987; Opler et al. 2004; Wasserman et al. 2000), polychlorinated biphenyls (Jacobson and Jacobson 1996), and ethanol (Lupton et al. 2004).

Because the literature has presented a range of possible consequences for methyl mercury toxicity, we have provided a range of possible public health and economic consequences. This range is meant to inform the choices that environmental and public health officials make in protecting vulnerable populations from methyl mercury exposure. Our range for the true economic costs of methyl mercury toxicity to the developing brain omits the cost of exposures to the 231,352 children born to women in 2000 with blood mercury concentrations between 3.5 and 4.84 μg/L. If the true cord blood ratio is 1.7 times the maternal blood concentration, as described in the most recent and extensive meta-analysis on the matter (Stern and Smith 2003), these children are also born with cord blood mercury concentrations above the 5.8 μg/L concentration at which adverse neurodevelopmental impact has been found. We chose not to include them in our analysis because other studies have found lower ratios and because we restricted ourselves in this analysis to the use of available, published prevalence data of maternal blood mercury concentrations. In our sensitivity analysis, we also selected low cord:maternal blood ratios so as to describe most accurately the range of values for the true cost of methyl mercury exposure to the developing fetus.

Our analysis also omits the cost of the cardiovascular impacts of mercury exposure (Grandjean et al. 2004) or the costs of mercury exposure to children in the first 2 years of postnatal life, when myelination is still continuing and the blood–brain barrier remains vulnerable to penetration by methyl mercury (Rodier 1995). We chose not to include these aspects of methyl mercury toxicity in our range of estimates at this time because there do not exist sufficient quantitative data to permit construction of a reliable model.

A limitation on our analysis is that it did not consider other societal costs beyond decreased lifetime earnings that may result from exposure of the developing brain to methyl mercury. For example, if the value of a child's social productivity is approximately $4–9 million, as suggested by studies of willingness-to-pay (WTP) estimates of a life (Viscusi and Aldy 2004), then by the WTP methodology the true cost of methyl mercury toxicity may be much higher than our estimate. We also chose not to include other noncognitive impacts. Lead, for example, has been associated with criminality and antisocial behavior (Dietrich et al. 2001; Needleman et al. 1996, 2002; Nevin 2000; Stretesky and Lynch 2001). However, because these behaviors have not been described as yet for methyl mercury, we chose not to include such costs in our estimate.

Some will argue that our range of costs fails to incorporate the role of confounding factors in quantifying the economic consequences of methyl mercury exposure. It is true that efforts

Table 1. Cost of anthropogenic mercury (Hg) exposure using a logarithmic model.

	Segment of population (percentile)			
Variable	90–92.1 Hg	92.2–94.9 Hg	95–99.3 Hg	≥ 99.4 Hg
Range of maternal total Hg concentration	4.84–5.8 μg/L	5.8–7.13 μg/L	7.13–15.0 μg/L	> 15.0 μg/L
Assumed maternal total Hg concentration	4.84	5.8	7.13	15
No effect concentration (maternal total Hg)	3.41	3.41	3.41	3.41
IQ points lost at assumed concentration	0.76	1.15	1.60	3.21
Loss of 1 IQ points = decrease in lifetime earnings				
For boys, lifetime earnings (1.931% decrease)	$1,032,002			
For girls, lifetime earnings (3.225% decrease)	$763,468			
No. of boys in birth cohort affected	45,693	58,155	91,387	12,462
No. of girls in birth cohort affected	43,601	55,492	87,201	11,891
Lost income	$1.1 billion	$2.0 billion	$4.4 billion	$1.2 billion
Total cost = $8.7 billion in each year's birth cohort				

Assumptions: EAF = 70%, main consequence = loss of IQ over lifetime.

Table 2. Sensitivity analysis: cost of anthropogenic methyl mercury exposure.

Variable	Base-case cost estimate (range)[a]
Children born to women with Hg > 4.84 μg/L, effect > 3.5 μg/L	
Logarithmic model	$8.7 billion ($4.9–13.9 billion)
Linear model, cord:maternal Hg ratio = 1.7	$32.9 billion ($20.9–43.8 billion)
Linear model, cord:maternal Hg ratio = 1	$19.3 billion ($12.3–25.8 billion)
Children born to women with > 5.8 μg/L, effect > 4.84 μg/L	
Logarithmic model	$3.9 billion ($2.2–6.3 billion)
Linear model, cord:maternal Hg ratio = 1.7	$18.7 billion ($11.9–24.9 billion)
Linear model, cord:maternal Hg ratio = 1	$11.0 billion ($7.0–14.6 billion)
Range of estimates	
Logarithmic model	$2.2–13.9 billion
Linear model	$7.0–43.8 billion

Assumptions: EAF = 70%, main consequence = loss of IQ over lifetime.
[a]Based on range of possible IQ decrement:increase cord blood mercury.

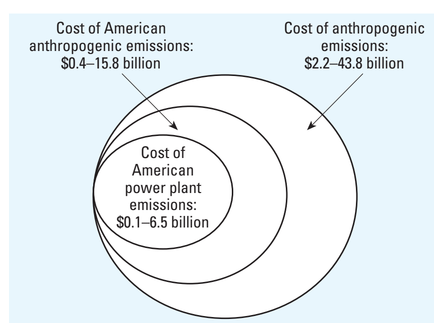

Figure 1. Portions of cost of methyl mercury exposure attributed to sources. Assumptions: 18–36% attributable to American sources; 41% of American emissions attributable to American power plants.

to delineate the potential synergistic role of methyl mercury and other chemicals in mediating neurocognitive and other effects are bedeviled by lack of knowledge about possible interactions and synergies among chemicals or between chemicals and other environmental hazards, even though the environment of a child includes mixtures of chemical and biologic toxicants. Only a study of the magnitude of the National Children's Study will facilitate simultaneous examination of the effects of multiple chemical exposures, of interactions among them, and of interactions among biologic, chemical, behavioral, and social factors (Trasande and Landrigan 2004). However, we note that loss of cognition resulting from methyl mercury exposure in the Faroe Islands study remained evident when blood levels of polychlorinated biphenyls, which are known fetal neurotoxicants (Jacobson and Jacobson 1996), were included in the analysis (Budtz-Jorgensen et al. 2002; Steuerwald et al. 2000).

We note the U.S. EPA's recent success in minimizing mercury emissions from medical waste (U.S. EPA 2004e) and municipal incinerators (U.S. EPA 2004f, 2004g), actions that resulted in a decrease in total mercury emissions by at least 80 tons per year from 1990 to 1999 (U.S. EPA 2003b). Although data are not available on blood mercury concentrations over the past decade that followed from those actions, the impact of these reductions is likely to have been substantial.

Some commentators have used data from the Seychelles study to argue that methyl mercury is not toxic to the fetus at low concentrations and to suggest that fear of mercury exposure is needlessly preventing women from ingesting fish and thus denying them access to beneficial long-chain polyunsaturated fatty acids (LCPUFAs), especially docosahexaenoic acid (DHA). We do not dispute that DHA and other LCPUFAs are important for optimal development of the fetal visual and nervous systems (Innis 1991). The human fetus has a limited ability to synthesize DHA's precursor, α-linolenic acid, and therefore it must be largely supplied from maternal sources (Carnielli et al. 1996; Larque et al. 2002; Szitanyi et al. 1999). We also note a report that associated an average monthly decline in fish consumption of 1.4 servings among Massachusetts women with a U.S. Food and Drug Administration advisory on the health risks of mercury (Oken et al. 2003). Nonetheless, the American Heart Association, a strong advocate for the cardioprotective effects of LCPUFAs, recommends that children and pregnant and lactating women avoid potentially contaminated fish (Kris-Etherton et al. 2002). Fish advisories should not recommend that consumers abstain from fish, but they should assist in choosing the best kinds of fish to eat. Lists of fish that are safe and unsafe from the perspective of mercury exposure have been published and made widely available to consumers (U.S. EPA 2004h).

Early reports of disease and dysfunction of environmental origin in children have on repeated occasions failed to produce proactive response to protect children. The long history of lead use in the United States provides a chilling reminder of the consequences of failure to act on early evidence of harm. It is important that we not repeat this sequence with mercury. Within the last century, as a result of increased industrial activity, mercury emissions worldwide have increased 2- to 5-fold, and anthropogenic emissions now surpass emissions from natural sources (Nriagu 1989).

The data from this analysis reinforce the results of recent epidemiologic studies and indicate an urgent need on economic grounds for regulatory intervention at the federal level to minimize mercury emissions. Our analysis captures the cost of methyl mercury exposure for only 1 year's birth cohort, but the cost of mercury exposure will continue to accrue in each succeeding year if power plants fail to install flue gas filters (U.S. Department of Energy 2004) or to implement other technologies to reduce mercury emissions. The cost savings from reducing mercury exposure now will provide savings in improved productivity and enhanced national security for generations to come.

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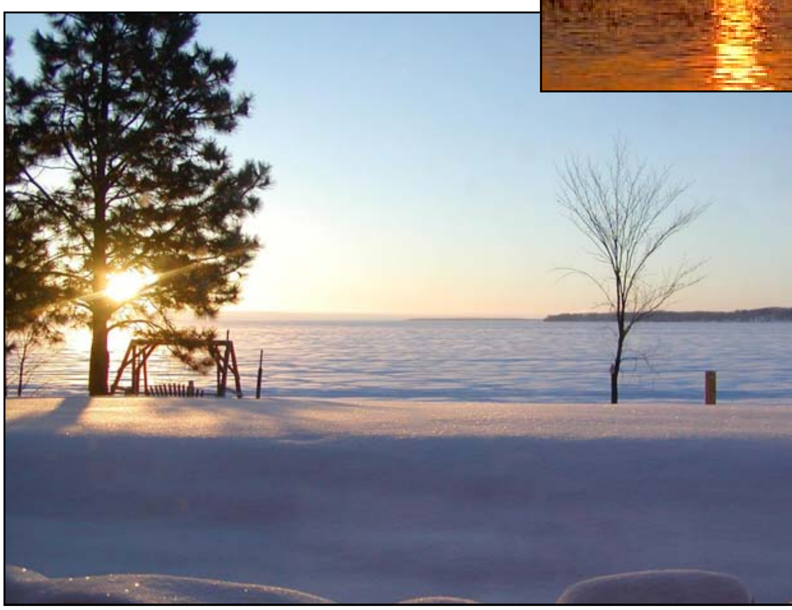
Leech Lake Association
Lake Management Plan



Leech Lake
ASSOCIATION

Second Edition: August 2012

The Voice of Leech Lake

among those traveling in Minnesota between June 2007 and May 2008, 37% of all expenditures were by tourists who stayed at the homes of family or friends and spent $4.12 billion, or were just passing through the state yet spent $315.14 million.

Demographic changes are also a factor influencing the resource use picture in this area. For example, the population of Cass County grew by 25% from 1990 to 2000, and was projected to grow at a similar rate over the next decade. Many of those moving to Leech Lake on a more permanent basis were originally resort customers who decided to move North in retirement, or could afford to during the housing boom of the late 1900's and early 2000's. However, the severe economic down-turn, sometimes referred to as "the great recession" starting in 2007 and only slowly diminishing in 2012, reduced the increase to just 5% in 2000-2010. Where around 1,400 Cass County zoning permits were granted in 2005 to 2007, only about 800 to 1,000 were obtained in 2008-2010. It remains to be seen whether the Cass County population growth rate will return to the previously projected high levels (64% by 2030, MN State Demographic Center, 2005) as state and national economies recover.

In 2011, 90 of the 165 new houses built in Cass County (54%) were on lakeshore lots (Cass County Planning and Zoning Office). Stretches that were once considered "undesirable" owing to shoreline vegetation, wetland proximity, offshore shallows, etc., are now being sought for development, often without adequate consideration of their intrinsic value to the lake. The conversion of older and smaller cabins into larger, more modern homes has also impacted shorelines. The net result is that shorelines which ought to be preserved or maintained for legitimate environmental or aesthetic reasons are now being reduced or eliminated with concurrent effects on water quality, or scenic beauty ('wildness'), or other irreplaceable attributes that make the lake such a highly valued natural resource. Two relatively new programs, the county Resource Protection Districts land use designation (*Cass County Land Use Ordinance, May, 2005*), and the creation of Conservation Easements, have been developed to protect critical and sensitive shoreland areas. These programs are discussed further in the Land Use and Zoning section of the Management Plan.

IV. THE STATE OF LEECH LAKE

Water Quality

Water quality is referred to in terms of its utility to support human recreational, domestic, and commercial uses; its suitability as habitat for fish and other wildlife; and the degree to which the water is different from other water bodies, or has changed since the advent of human influences. The kinds of measurements employed to judge water quality are usually determined by the kinds of human activity or land use in the surrounding area. In the case of Leech Lake, contaminants from industrial sources would likely not be present unless they were highly persistent and transported long distances. On the other hand, inputs from domestic uses or nearby commercial land use practices such as logging could have an influence on water quality. Fish or wildlife inhabitants can sometimes provide clues about the condition of the water or the nature of disturbances. The most common potentially solvable water quality problem for lakes in the sparsely populated recreational lakes area of North Central Minnesota is nutrient enrichment, or eutrophication, from leakage of individual wastewater elimination systems.

Storm water runoff from lakeshore development and municipalities can also be a problem. The town of Walker has a number of storm sewers that empty into Leech Lake next to the urban housing and business area. With two exceptions that go to settling ponds, these effluent streams carry street and yard residues directly into the lake during periods of even moderate rainfall. The city Department of Public Works is concerned about this problem and seeking help to address the issue. The Leech Lake Association will work with the Cass County Environmental Services Department and City of Walker to try to find the means to remedy this source of pollution. The additional practice of managing run-off by directing precipitation off roofs and driveways into rain gardens, or otherwise into the ground where it falls, would also help. Lots of information on such practices is available from the Cass County Environmental Service Department in Walker.

Water quality data have been collected for Leech Lake off and on since 1972 (U.S. EPA STORET Legacy Database, http://www.epa.gov/storet.html.). Citizen volunteers from Leech Lake have participated in the Minnesota Pollution Control Agency's (MPCA) Citizen Lake Monitoring Program by recording Secchi depth, a measure of water transparency. Gerald Trimble, George Smith, Jerry Roehl, and Donald L. Bartsch have been the primary volunteers recording these data for Leech Lake. Dennis Leff and Don Flycht of the Leech Lake Association have likewise collected water samples and taken secchi disc readings. In addition, many agencies monitor water quality on the lake, including the MN Pollution Control Agency, MN Department of Natural Resources, Leech Lake Band of Ojibwe, and U.S. Army Corps of Engineers.

Because nutrient enrichment is the most likely impairment candidate, three response-related measurements have been recorded most frequently to judge water quality: phosphorus, a highly nutritious (to algae) component of domestic wastes and fertilizer; chlorophyll *a*, which reflects the concentration of algae utilizing the phosphorus for photosynthesis; and Secchi disc depth or transparency, which is inversely related to the algae concentrations. These measurements are used together to calculate a trophic state index, or TSI (Carlson 1977), which is indicative of the total weight of living biological material or biomass in a water body at a specific location and time.

Data sets for calculating TSIs using total phosphorus and chlorophyll *a* are very limited for all sites on Leech Lake (RMB Environmental Labs, 2008a). The results indicate that Walker Bay is weakly mesotrophic (relatively less productive), Agency and Kabekona Bays are more strongly mesotrophic (moderatly productive), and the Main Basin, Steamboat Bay and Shingobee Bay are the most mesotrophic (quite productive). Collecting more data would better explain the pattern and the relationship between phosphorus, chlorophyll *a* and transparency in Leech Lake. Continuation of the MPCA Citizen Lake and Stream Monitoring Program, and the MNPCA's Leech Lake River Intensive Watershed Monitoring effort starting in 2012, should help in this regard. Fourteen years of transparency data indicate that a statistically significant increase has occurred in Steamboat Bay. The reason for this is unclear, and there are insufficient data to detect trends for other variables or parts of the lake.

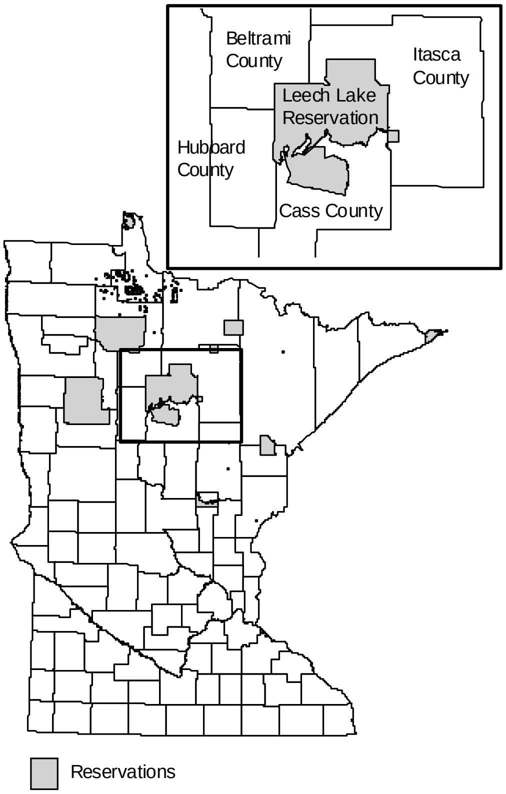
Minnesota is divided into seven ecoregions based on land use, vegetation, precipitation and geology. Leech Lake is in the Northern Lakes and Forests (NLF) Ecoregion. The MPCA has

January 2017

American Indians, Indian Tribes, and State Government

Research Department
Minnesota House of Representatives

Leech Lake



Minnesota Chippewa Tribe Member

190 Sailstar Drive NW
Cass Lake, MN 56633
218-335-8200
218-335-8309 (Fax)
www.llojibwe.com

Adjacent Counties: Beltrami, Cass, Hubbard, and Itasca counties

Nearby Cities: Bemidji, Deer River, Grand Rapids, Walker

***Tribal Enrollment (2016)*:** 9,465

Tribal Land: 14,782.75 acres

Individual Land: 12,252.11 acres

***Government Land*:** 140 acres

Casinos:

Northern Lights Casino
6800 Y Frontage Road NW
Walker, MN 56484
800-252-7529
northernlightscasino.com

White Oak Casino
45830 U.S. Highway 2
Deer River, MN 56636
800-653-2412
www.whiteoakcasino.com

Palace Casino Hotel
16599 ï 69th Ave NW
Cass Lake, MN 56633
877-972-5223

Top Three Industries on Reservation: Education, health, and social services (24.4 percent); arts, entertainment, recreation, accommodation, and food services (23.1 percent); retail trade (9.7 percent)

Tribal College:
Leech Lake Tribal College
Cass Lake (Cass County)

Tribal Governance: Governed by five-member Reservation Business Committee (commonly referred to as Reservation Tribal Council), composed of a tribal chair, secretary/treasurer, and three regional representatives.

Tribal Chairman (Term expires June 30, 2020):
Faron Jackson, Sr.
faron.jackson@llbo.org
218-335-8200

Demographics of Leech Lake Reservation and Surrounding Areas

Population

	Population	American Indian Population	% American Indian	% of MN American Indian Population
Leech Lake	10,848	4,828	44.5%	4.7%
Adjacent Counties	139,556	16,954	12.1%	16.6%
State	5,383,661	102,060	1.9%	100.0%

Age

	% Under Age 18	% Age 18 to 64	% Age 65 and Over
Leech Lake	27.5%	54.8%	17.7%
Adjacent Counties	22.6%	58.6%	18.8%
State	23.8%	62.6%	13.6%

Income

	Median Household Income	Per Capita Income	% with Income Below Poverty Level	% with Cash Public Assistance Income
Leech Lake	$39,115	$19,225	22.7%	9.3%
Adjacent Counties	$45,685	$23,865	14.9%	4.8%
State	$60,828	$30,310	11.0%	3.3%

Labor

	% Population Age 16+ in Labor force	% Labor Force Employed	% Labor Force Unemployed
Leech Lake	57.9%	49.4%	14.6%
Adjacent Counties	60.6%	55.3%	8.7%
State	70.1%	65.5%	6.5%

Education

	% of Pop. Age 25+ Less than HS Grad	% of Pop. Age 25+ HS Graduate Only	% of Pop. Age 25+ Some College or Associate Degree	% of Pop. Age 25+ Bachelor's or Graduate Degree
Leech Lake	11.3%	34.5%	37.9%	16.3%
Adjacent Counties	8.6%	31.7%	36.4%	23.3%
State	7.7%	26.4%	32.7%	33.2%

LLBO Boundary Waters

Lakes and Rivers

NAME	WATERBODY TYPE	ACRES
Bag	Lake or Pond	20.21
Bowstring	Lake or Pond	9528.17
Boy	Lake or Pond	3465.94
Dixon	Lake or Pond	622.42
Four Towns	Lake or Pond	277.13
Hazel	Lake or Pond	14.74
Inguadona	Lake or Pond	1132.93
Inguadona (N. Bay)	Lake or Pond	359.34
Leech	Lake or Pond	110309.91
Leech (Kabekona Bay)	Lake or Pond	960.94
Leech (Main Basin)	Lake or Pond	109348.97
Leech (Shingobee Bay)	Lake or Pond	368.50
Little Whitefish	Lake or Pond	160.40
Moose	Lake or Pond	600.71
Mud	Lake or Pond	81.97
Natures	Lake or Pond	2248.64
Pimushe	Lake or Pond	1230.44
Rice	Lake or Pond	790.51
Steamboat	Lake or Pond	1755.68
Swenson	Lake or Pond	411.78
Taylor	Lake or Pond	34.37
White Oak	Lake or Pond	942.47
Winnibigoshish	Lake or Pond	56471.63
Wolf	Lake or Pond	1073.39
Ball Club River	River	
Big Fork River	River	
Boy River	River	
Crane Creek	River	
Dunbar River	River	
Grouse Creek	River	
Island Lake Creek	River	
Jessie Brook	River	
Leech Lake River	River	
Mississippi River	River	
Popple River	River	
Sixmile Brook	River	
Third River	River	
Vermillion River	River	

TEMPLATE FOR TAS APPLICATION – WQS AND WATER QUALITY CERTIFICATION PROGRAMS

Leech Lake Band of Ojibwe

APPLICATION FOR CLEAN WATER ACT ELIGIBILITY TO ADMINISTER A WATER QUALITY STANDARDS PROGRAM AND A WATER QUALITY CERTIFICATION PROGRAM

The Leech Lake Band of Ojibwe ("Tribe" or "Band") has separately submitted its Clean Water Act TAS Application ("Application") to the U.S. Environmental Protection Agency to become eligible to be treated in a similar manner as a state ("TAS") under the Clean Water Act ("CWA") to administer a CWA section 303(c) water quality standards program and CWA section 401 water quality certification program. The Tribe submits this document as an addendum to its Application to cross-reference information contained in its TAS Application.

1. BACKGROUND

See Application, at p.1.

2. FEDERAL RECOGNITION (40 CFR 131.8(a)(1) and (b)(1))

This Tribe is listed as "Leech Lake Band of the Minnesota Chippewa Tribe of the Leech Lake Reservation" in the Secretary of the Interior's list of federally recognized tribes at 82 Fed. Reg. 4915, (January 17, 2017). *See* Application, at § I.

3. AUTHORITY OVER A FEDERAL INDIAN RESERVATION (40 CFR 131.8(a)(1) and 131.3(l))

This Tribe exercises governmental authority over a federal Indian reservation. *See* section 5 of this document below and Application, at § III for more information about the description of the Tribe's reservation lands.

4. TRIBAL GOVERNANCE (40 CFR 131.8(a)(2) and (b)(2))

The Leech Lake Band of Ojibwe has a governing body carrying out substantial governmental duties and powers. *See* the Tribe's previous TAS application for the CWA Sections 106 and 314 program submitted to and approved by EPA on June 20, 1995; *see also* Application, § II, and attachment 1.

5. MANAGEMENT AND PROTECTION OF WATER RESOURCES OF THE RESERVATION (40 CFR 131.8(a)(3) and (b)(3))

The water quality standards and water quality certification programs to be administered by the Tribe will assist in managing and protecting water resources within the borders of the Tribe's reservation.

The boundaries of the Indian reservation areas for which the Tribe is seeking authority to administer the water quality standards and water quality certification programs are identified in the attached maps and legal description. *See* Application, § III.a, and attachments 12-13. This includes the waters within the exterior boundaries of the Leech Lake Reservation.

The surface waters for which the Tribe proposes to establish water quality standards are those surface waters that occur on the reservation areas described in the map(s) and legal description provided above. These include the following named waters and their tributaries that occur within those areas: *see* Application, § III.D., and attachments 15-16.

6. TRIBAL LEGAL COUNSEL STATEMENT (40 CFR 131.8(b)(3)(ii))

The basis for the Tribe's assertion of authority under this application is the express congressional delegation of authority to eligible Indian tribes to administer regulatory programs over their reservation contained in section 518 of the Clean Water Act. This authority is described in the U.S. Environmental Protection Agency's final interpretive rule, *Revised Interpretation of Clean Water Act Tribal Provision*, 81 FR 30183, May 16, 2016. There are no limitations or impediments to the Band's authority or ability to effectuate the delegation of authority from Congress as described in this application.

Additionally, a statement by the Tribe's legal counsel providing references to the documents that established the Tribe's reservation lands, and describing the basis of the Tribe's assertion of authority, is provided separately. *See* Legal Analysis Demonstrating Basis for Leech Lake Band of Ojibwe's Assertion of Authority to Regulate Reservation Water Quality and be Treated in the Same Manner as a State Pursuant to Sections 303 and 401 of the Clean Water Act, Attachment 14 to the Application ("TAS Jurisdictional Analysis").

Furthermore, the Tribe's reservation areas described in section 5 of the application were established in the following documents: *See* Application, at §§ II, III, and attachments 2-7; *see also* TAS Jurisdictional Analysis. Finally, the Tribe's constitution and ordinances demonstrate the Tribe's exercise of authority in general over the reservation. *See* Application, at §§ II, III, and attachments 1, 8-9; *see also* TAS Jurisdictional Analysis.

There are no limitations or impediments to the Tribe's authority or ability to effectuate the delegation of authority from Congress as described in this application.

7. TRIBAL CAPABILITY

The Tribe is capable of administering effective water quality standards and water quality certification programs, as described below.

The overall organization of the Tribe's government and experience in managing programs, such as environmental or public health programs, is described in Application, §§ II, IV.

The responsibilities to establish, review, implement and revise water quality standards will be assigned to the Water Resources Program. *See* Application, §§ IV.A, IV.B.

The Tribal entity that will be responsible for conducting water quality certifications under CWA section 401 is the Director of the Division of Resource Management. *See* Application, § IV.A.

Experienced staff members are already on board and trained to administer the water quality standards and certification programs. *See* Application, §§ IV.A, IV.B, IV.C.1.