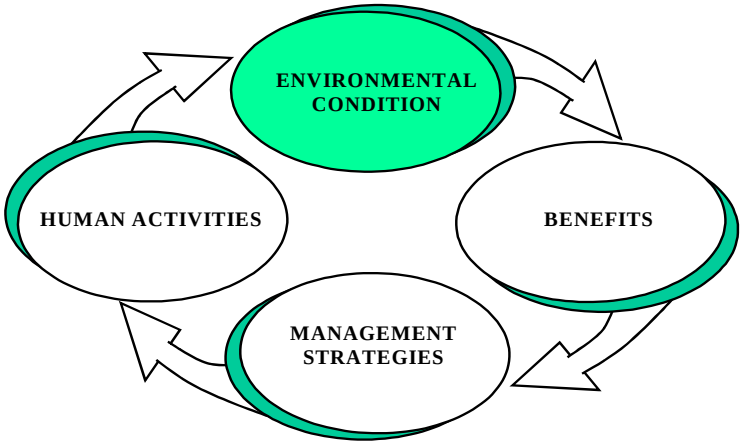
INDICATOR **F** *ACTSHEET* SUSTAINING MINNESOTA'S LAKES

Phosphorus Concentration



"Nutrients are the primary pollutants that degrade water quality below designated-use thresholds, and phosphorus is the most significant of these."
–Minnesota's 1994 Report to Congress, 305(b)

What is phosphorus?

Phosphorus, a necessary nutrient for both plants and animals, occurs naturally in many minerals. It is also found in organic material: dead leaves, lawn clippings, manure, and sewage. Phosphorus also is a major ingredient of agricultural fertilizers.

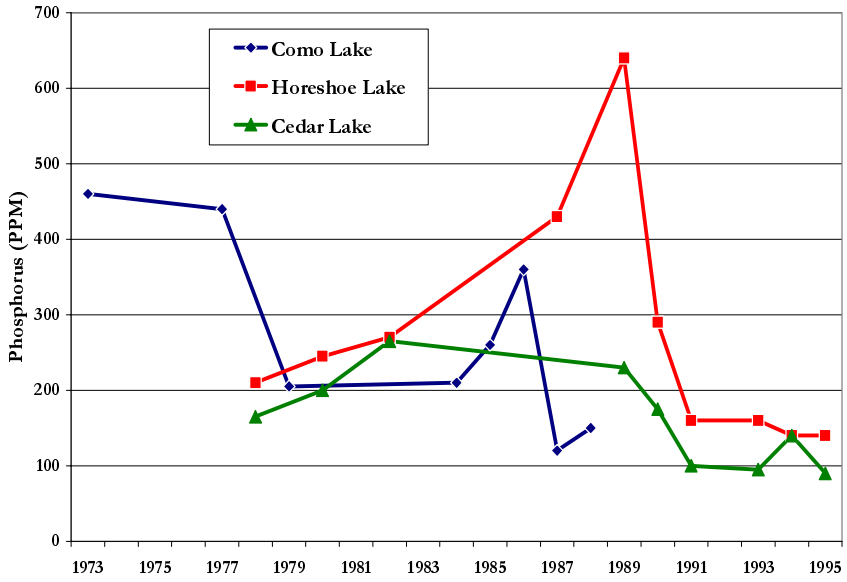
In lakes, phosphorus is usually in short supply compared to carbon, nitrogen, and other major elements needed by living things. Lake organisms, particularly algae, often have plenty of everything they require for growth and reproduction except phosphorus.

Some phosphorus dissolves into lake water from surrounding rock (Wetzel 1983), but most phosphorus finds its way into lakes through human activity. Phosphorus binds to soil particles and is transported whenever wind or water move sediment. Runoff from farms and feedlots and seepage from lakeshore septic systems are major sources of phosphorus in lakes (MPCA 1997).

When can phosphorus be a problem?

When large amounts of phosphorus enter a lake, algae reproduce explosively, tinting the water green and collecting in slimy mats on the surface. This algal "bloom" may bother swimmers and boaters. But more importantly, algal blooms are part of a cascade of ecological changes called eutrophication, an increase in lake fertility which can eliminate desirable game fish and many other species. Eutrophication occurs naturally over centuries, but influxes of phosphorus can speed up the process, transforming a lake in just a few years or decades.

Phosphorus Concentrations in Three Lakes in the North Central Hardwood Forest Ecoregion



During an algal bloom, floating algae clouds the water and blocks sunlight needed by rooted plants under water. Over time, this can kill off beds of "water weeds" which are breeding and nursery habitat for game fish and many other animals (Boynton 1997).

As the algae dies, it sinks to the bottom and decays. Decay bacteria proliferate and use up oxygen needed by fish and other aquatic organisms. Low oxygen levels also allow chemical changes in the water which release still more phosphorus form lake sediments. As eutrophication progresses, many species disappear from the lake. Lake trout, which need oxygen-rich water, are among the first game fish to go (Tester 1995). Bass and walleye tolerate lower oxygen levels, but as eutrophication progresses, they too will die. Carp and catfish tolerate very low levels of dissolved oxygen and may be the last fish left in a eutrophic lake.

How is phosphorus concentration measured?

Total phosphorus (TP) is the most commonly used measurement of phosphorus content (MPCA 1997). This includes phosphorus bound to suspended sediment and contained in floating algae, as well as P dissolved in water.

To measure the phosphorus content of a lake, water samples must be collected. Often this is done with an "integrated sampler," a two-meter plastic tube open at both ends. The tube is lowered in the water, then corked at the top end and drawn up. This samples water throughout the top two meters of water, giving a more complete picture than water scooped off the surface.

Water samples can be collected by trained lay people, but chemical analysis of TP requires specialized laboratory equipment. In the lab, the water is treated with a dye that binds to phosphorus. The dyed samples are analyzed in a spectrophotometer, which passes a beam of light through the water to determine phosphorus concentration.

Phosphorus levels in a lake can vary widely from site to site and from season to season. It is important to know when and where to sample. Often, phosphorus levels are highest in spring, when lake water layers mix and nutrients move up from the bottom sediments. Since runoff carries phosphorus off the land, phosphorus levels may rise temporarily after snow melts or heavy storms. Samples taken near a feedlot or a leaking septic tank may contain more phosphorus than samples from deep in the lake. Samples from near the bottom may contain more phosphorus than samples take at the surface. Samples from many areas of the lake may be averaged to get a mean TP for the whole lake, or samples from different areas may be kept separate to pinpoint potential sources of phosphorus pollution. To get the best picture of overall phosphorus levels in a lakes, some experts recommend sampling in the summer (after spring runoff and turnover) and from the epiliminion, or upper layer of water (away from

Most Sensitive Lake Uses and Their Phosphorus Criteria by Ecoregion

ECOREGION	MOST SENSITIVE USE	P LEVEL
Northern Lakes and Forests	Drinking water supply	<15 ppb
	Cold water fisheries	<15 ppb
	Swimming and aesthetics	<30 ppb
North Central Hardwood Forests	Drining water supply	<30 ppb
	Swimming and aesthetics	<40 ppb
Western Corn Belt Plains	Drinking water supply	<40 ppb
	Swimming and aesthetics	
	- full support	<40 ppb
	- partial support	<90 ppb
Northern Glaciated Plains	Recreation and Aesthetics	
	- partial support	<90 ppm

phosphorus-rich sediment at the bottom (Nurnburg 1996). To minimize the effect of random variation in the water samples, it's best to take several samples at each time and place, then average their TP readings.

Phosphorus concentration in unpolluted waters vary from less than 1 part per billion (ppb) to more than 200 ppb, depending on local geology and the natural level of organic material in the water (Wetzel 1983). In Minnesota, the total phosphorus concentration of a pristine lake might fall between 10 and 50 ppb. Effluent from Minnesota wastewater plants typically contains 200-300 ppb of total phosphorus (Heiskary and Walker 1995).

In Minnesota, phosphorus concentration is monitored by MPCA's Lake Assessment Program, the Metropolitan Council's lake program, MPCA's Lake Monitoring Program, and other lake monitoring programs (Heiskary and Walker 1988).

Can we use this indicator now?

Yes. TP is one of the most commonly used metric for evaluating impacts of eutrophication and setting water-quality standards across North America (MPCA 1997).

Concentration of phosphorus can be correlated with other indicators of lake water quality, such as Secchi disk transparency, chlorophyll-a concentration, and frequency of algal blooms. With background data on a lakes' phosphorus budget, concentration of phosphorus can be used to predict algal blooms and allow managers to take steps to stop eutrophic changes (Heiskary and Walker 1988).

What are the limitation of using phosphorus concentration as an indicator?

The impact of phosphorus on a lake depends on many things: geology, circulation, temperature, etc. (Boynton 1997, Heiskary and Walker 1988). Some lakes are ecologically equipped to absorb more phosphorus than others. Therefore, it is difficult to set one P standard to protect water quality across a large, diverse region. MPCA recognized this, dividing Minnesota into four ecoregions, each with a separate standard for allowable total phosphorus (MPCA 1997).

Even within a region, different lakes may respond differently to phosphorus inputs, based on factors like depth, orientation to prevailing winds, and land uses along shore. Phosphorus standards may be best developed on a lake-by-lake basis.

There's also a related, social factor: where lakes are naturally eutrophic, lake users are more tolerant of algae (Heiskary and Walker 1988, Smeltzer and Heiskary 1990).

Northern Minnesotans, used to clear oligotrophic lakes, report algae nuisance at much lower algae concentrations than residents of southeastern Minnesota. A phosphorus standard designed to protect recreational benefits should take into account local expectations for water quality, as well as the natural tropic status of the lake.

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