# Part 2
# The Concept of Limiting Nutrients

*Marilyn Bachmann*

A limiting nutrient is a chemical necessary for plant growth — but is available in smaller quantities than needed for algae to increase their abundance. Once the limiting nutrient in a waterbody is exhausted, the population of algae stops expanding. If more of the limiting nutrient is added, larger algal populations will result until their growth is again limited by nutrients or by other limiting environmental factors.

It's helpful to know if there is a limiting nutrient (or some other limiting factor) in your lake, as an increase of the limiting nutrient could affect change in the lake.

There are many potentially limiting nutrients. For example, silica is sometimes known to limit the growth of diatoms. Although scientists may debate which nutrient is the limiting factor at any given time, phosphorus and nitrogen are most often the limiting nutrients in Florida waterbodies.

## About Phosphorus

Phosphorus is an element that, in its different forms, stimulates the growth of algae in waterbodies. Phosphorus compounds are also found naturally in many types of rocks and soils. In fact, phosphorus is mined in Florida and other parts of the world for a variety of agricultural and industrial uses. In most freshwater lakes in Florida, the limiting nutrient is believed to be phosphorus rather than nitrogen.

The chemical symbol for the element **phosphorus** is **P**.

In waterbodies, phosphorus occurs in two forms: **dissolved** and **particulate**.

**Dissolved phosphorus** is defined based on its size, as that which is small enough to pass through a 0.45 micron filter. It includes phosphorus forms like soluble reactive phosphorus and soluble organic compounds that contain phosphorus.

Its counterpart **particulate phosphorus**, is too big to pass through a 0.45-micron filter. It is formed when phosphorus becomes incorporated into particles of soil, algae, and small animals that are suspended in the water. Both dissolved and particulate phosphorus can change from one form to another very quickly (called cycling) in a water body and there is ongoing scientific inquiry about when, where, and how often these specific forms of phosphorus are found in waterbodies. This is important because algal cells and plants can only use phosphorus in certain forms.

Understanding the relationship between algae and phosphorus is further complicated by the fact that an algal cell's ability to use specific forms of phosphorus is strongly influenced by several factors including pH, water hardness (caused by the presence of calcium and/or magnesium), the amount of dissolved oxygen in the water, and thermal stratification (layers of water having different temperatures).

This process of phosphorus cycling makes it difficult to measure dissolved or particulate phosphorus in a waterbody at a given time. However, **total phosphorus** concentrations (abbreviated TP), which include both dissolved and particulate forms, can be used to gain an estimate of the amount of phosphorus in a system. Florida LAKEWATCH measures total phosphorus because it provides a snapshot of the total phosphorus concentrations in a lake at a given time.

**There are many ways in which phosphorus compounds find their way into waterbodies. Some of the more common pathways are described as follows:**

♦ Some areas of Florida and other parts of the world have extensive phosphate deposits in the soils. In these areas, rivers and water seeping or flowing underground can become phosphorus enriched and may carry significant amounts of phosphorus into waterbodies.

♦ Sometimes phosphorus is added intentionally to waterbodies as a management strategy to increase fish production by fertilizing aquatic plant and algal growth.

♦ Phosphorus can enter waterbodies inadvertently as a result of human activities like landscape fertilization, crop fertilization, wastewater disposal, and stormwater run-off from residential developments, roads, and commercial areas.

**Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998, had total phosphorus concentrations which ranged from less than 1 to over 1000 µg/L** (0.001 to 1 mg/L)**. Analysis of total phosphorus concentrations in Florida shows the following relationships. These relationships should be of interest to anyone trying to manage phosphorus concentrations in a Florida lake—and are important to consider when attempting to evaluate the feasibility of goals you or others may set for phosphorus levels in a waterbody.[1]**

**There seems to be a relationship between the location of a waterbody and its total phosphorus concentration.**

For example, lakes in the New Hope Ridge/Greenhead Slope Lake Region✪ of northwestern Florida (in Washington, Bay, Calhoun, and Jackson counties) tend to have extremely low total phosphorus values (below 5 µg/L). While lakes in the Lakeland/Bone Valley Upland Lake Region of central Florida (in Polk and Hillsborough counties) tend to have very high values (above 120 µg/L).[2]

✪ *Lake Regions are geographical areas in which lakes have similar geology, soils, chemistry, hydrology, and biological features. In 1997, using Florida LAKEWATCH data and other information, the United States Environmental Protection Agency designated 47 lake regions in Florida using these similarities as their criteria. For more information, see Lake Regions in the Appendix A.*

**Using the Florida LAKEWATCH database, it can be shown that there is a seasonal pattern for total phosphorus concentrations in Florida lakes.**

Monthly total phosphorus concentrations tend to be lower during December and January, but higher and more variable during the rest of the year. Typically, the maximum measured total phosphorus concentration occurs most frequently in August and October or from February through May in some lakes. Minimum measured total phosphorus concentrations occur most frequently from November through February.

**1** *For more information on a specific LAKEWATCH waterbody, you can call the Florida LAKEWATCH office (1-800-LAKEWATCH) and request a data packet for that waterbody. It's also recommended that you refer to the following LAKEWATCH handouts—* ***Florida Lake Regions: A Classification System****;* ***Trophic State: A Waterbody's Ability to Support Plants, Fish, and Wildlife****; and* ***Florida LAKEWATCH Data — What Does It All Mean?***

**2** *Total phosphorus concentrations in an individual waterbody may not be at these levels all the time; they can be quite variable over time.*

## A Bum Rap

Because waterbodies with low concentrations of total phosphorus (TP) will have relatively clear water, the public may think their water quality is better than waterbodies with higher TP. It's a misconception however, that clearer water is intrinsically better than water that is less clear.

Unfortunately, the association of clear water with low phosphorus levels has given the public the mistaken notion that phosphorus is a pollutant.

Amy Richard

## Total Phosphorus and Biological Productivity

One major task that lake experts are faced with in water quality management is assessing the **biological productivity** of a waterbody — and determining whether it's changing over time. However, overall biological productivity is difficult to measure in a waterbody because it involves measuring many different parameters over a period of time. Such an approach would be prohibitively expensive and time consuming. Because of this, many aquatic scientists use **total phosphorus** measurements, often alone, as an indirect way of assessing the biological productivity of a waterbody.

Why?

Because phosphorus is one of the main nutrients that can limit the biological productivity of a waterbody. However, this is not always the most accurate way to assess the biological productivity of a waterbody. Other factors may also limit biological productivity, such as availability of light.

☛ *See **Color** and **Humic acids** in Appendix B.*

**Biological Productivity** is the amount of algae, aquatic plants, fish, and wildlife that a waterbody can produce and sustain.

☛ *For more information, see **Part 4 Limiting Environmental Factors Other Than Nutrients** on page 23.*

## Trophic State

While discussing a lake's biological productivity with aquatic scientists, you may hear the term **trophic state**. Trophic state is just another way of saying biological productivity. The **Trophic State Classification System** is one method scientists use to quickly and easily describe the biological productivity of a waterbody. It's one of the more commonly used systems worldwide and is used by Florida LAKEWATCH.

The Trophic State Classification System classifies lakes and/or waterbodies into one of four trophic states:

- ♦ waterbodies with low productivity are called **oligotrophic** (oh-lig-oh-TROH-fic);
- ♦ those with moderate productivity are called **mesotrophic** (mes-oh-TROH-fic);
- ♦ moderate-to-highly productive waters are called **eutrophic** (you-TROH-fic);
- ♦ and highly productive waters are called **hypereutrophic** (HI-per-you-TROH-fic).

☛ *For more information, see **Trophic state** and **Trophic State Index** in Appendix B.*

## Phosphorus As A Limiting Nutrient

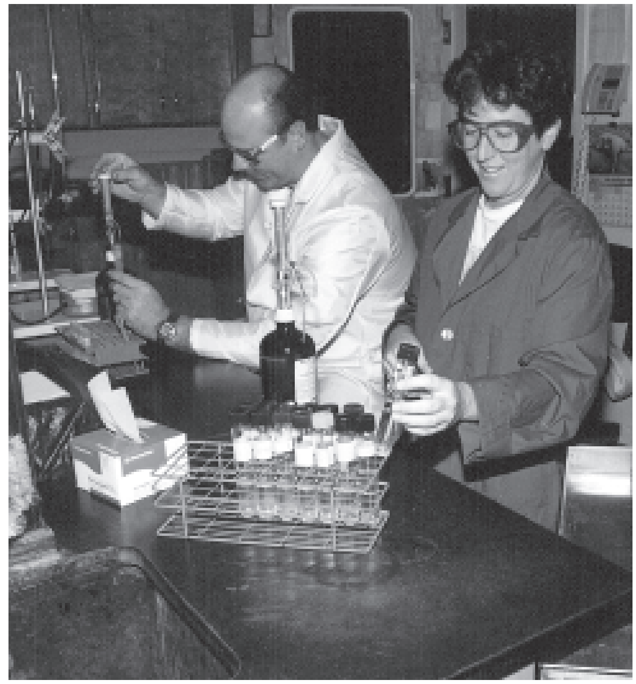
Because phosphorus is frequently the limiting nutrient in the growth of free-floating algae in lakes, it is strongly believed in the scientific community that waterbodies with *higher* phosphorus levels will have *higher* levels of algae and waterbodies with *low* phosphorus concentrations will have *lower* levels of algae. This belief is based in part on surveys of lakes, both in Florida and throughout the world, and on results of whole-lake experiments.

A picture of this relationship emerges when average yearly chlorophyll concentrations, from a group of LAKEWATCH lakes, are plotted on a graph versus the total phosphorus concentrations. (See Figure 1 on page 8.) The graph shows that increasing phosphorus values are generally accompanied by increasing chlorophyll levels.[3]

Consequently, aquatic scientists almost always recommend the manipulation of phosphorus, called phosphorus control, as a primary management strategy for controlling algal biomass.

The high priority placed on phosphorus control by regulatory and professional management agencies in Florida is evidenced by its use in the multi-million dollar lake management programs at Lake Apopka and Lake Okeechobee.

However, phosphorus is not always the limiting nutrient and phosphorus removal may not be the best management approach to controlling algal biomass.



*Joe Richard*

☛ *See* ***Determining the Limiting Nutrient In A Waterbody*** *(page 11);* ***Part 3 Using Models to Predict Algal Abundance*** *(page 17); and* ***Limiting Environmental Factors Other Than Nutrients*** *(page 23).*

**3** *This relationship is indicated by the observation that the points in the graph that are further to the right are also generally higher up. The correlation is true in spite of the fact that chlorophyll concentrations can be highly variable for any specific total phosphorus concentrations.*

**4** *This distribution of trophic state is based solely on total phosphorus values without utilizing information on nitrogen concentrations, chlorophyll concentrations, Secchi depth, or aquatic plant abundance.*

## Total Phosphorus and Trophic State

Using ONLY average concentrations of total phosphorus (TP) from the Florida LAKEWATCH database, Florida lakes were found to be distributed into the four trophic states as described below.[4]

♦ Approximately 42% of the lakes (those with TP values less than 15 µg/L) would be classified as **oligotrophic**. *Oligotrophic lakes have very low levels of biological productivity.*
♦ About 20% of the lakes (those with TP values between 15 and 25 µg/L) would be classified as **mesotrophic**. *Mesotrophic lakes have moderate levels of biological productivity.*
♦ 30% of the lakes (those with TP values between 25 and 100 µg/L) would be classified as **eutrophic**. *Eutrophic lakes have moderately high levels of biological productivity.*
♦ Nearly 8% of the lakes (those with TP values greater than 100 µg/L) would be classified as **hypereutrophic**. *Hypereutrophic lakes have very high levels of biological productivity.*

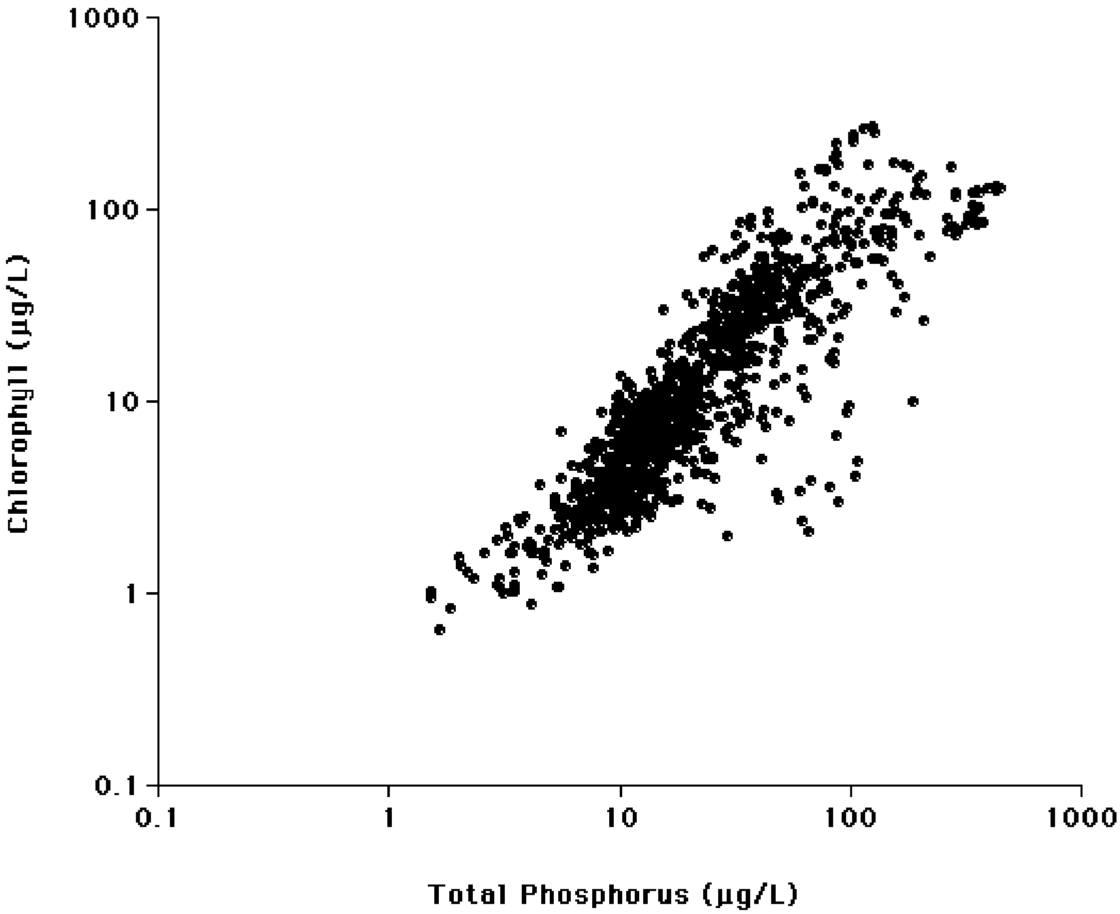



**Figure 1.**
The relationship between total phosphorus concentrations and total chlorophyll concentrations for Florida lakes.

**The graph shown here in Figure 1 is a scatter plot graph**. Scatter plot graphs are good for plotting more than one type of measurement on the same graph. Notice how this scatter plot graph represents both total chlorophyll and total phosphorus concentrations at the same time. You'll see more of these types of graphs in this circular as well as water management publications, meetings, and seminars.

**While studying this graph**, you may also notice that the numbers on each axis are represented in multiples of 10. It's arranged this way because this particular scatter plot graph is formatted using a common logarithmic scale.[5] Rather than plotting the phosphorus and chlorophyll concentrations directly, we plotted logarithms of the concentrations. By using this type of logarithmic scale, we were able to stretch out the scale at the lower end of the graph so that more of the individual points could be seen.

☛ For more on **logarithmic scales** see Appendix A.

**5** *Remember that common logarithms are the exponents of the number 10. For example in the equation* $10^2 = 100$*, we can see that the logarithm of 100 is 2. And using the equation* $10^3=1000$*, we can see that the logarithm of 1000 is 3. Similarly, the equation* $10^1=10$ *tells us that the logarithm of 10 is 1.*

# About Nitrogen

The chemical symbol for the element **nitrogen** is **N.**

Nitrogen is also a necessary nutrient for the growth of algae and aquatic plants. Various forms of nitrogen can be found in water including organic and inorganic forms.

**Organic** forms of nitrogen are derived from living organisms and include amino acids and proteins.

**Inorganic** forms are composed of materials other then plants or animals (i.e., mineral based) and include nitrate ($N0_3^-$), nitrite ($N0_2^-$), unionized ammonia ($NH_4$), ionized ammonia ($NH_3^+$), and nitrogen gas ($N_2$).

**Total nitrogen** (abbreviated **TN**) is a measure of all the various forms of nitrogen found in a water sample, except nitrogen gas. Not all forms of nitrogen can be readily used by algae — especially nitrogen bound with particulate organic matter. In general, algae and aquatic plants directly utilize inorganic forms of nitrogen such as nitrates, nitrites, and ammonia.

**Nitrogen finds its way into aquatic environments from both natural and man-made sources including:**

- **the air** — some algae can "fix" nitrogen, or pull nitrogen out of the air in its gaseous form and convert it to a form they can use;
- **stormwater run-off** — nitrogen can even come from "natural" run-off from areas where there is no human impact because it is a naturally-occurring nutrient found in soils and organic matter;
- **fertilizers**; and
- **animal and human wastes** (sewage, dairies, feedlots, etc.).

**Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998, had total nitrogen concentrations which ranged from 50 to over 6000 µg/L** (0.05 to 6 mg/L)**. Analysis of total nitrogen concentrations in Florida shows the following relationships that should be of interest to anyone trying to examine nitrogen concentrations in their lakes. As with phosphorus, these relationships provide a useful background against which a waterbody manager can evaluate the feasibility of specific management goals.**

♦ **The location of a waterbody has an important effect on its total nitrogen concentration.**

For example, lakes in the New Hope Ridge/Greenhead Slope Lake Region✪ in northwestern Florida (Washington, Bay, Calhoun, and Jackson counties) tend to have very low total nitrogen values (below 220 µg/L). While lakes in the Lakeland/Bone Valley Upland Lake Region in central Florida (Polk and Hillsborough counties) tend to have high values (above 1700 µg/L).

✪ *Lake Regions are geographical areas in which lakes have similar geology, soils, chemistry, hydrology, and biological features. In 1997, using Florida LAKEWATCH data and other information, the United States Environmental Protection Agency designated 47 lake regions in Florida using these similarities as their criteria.*

☛ *For more information, see **Lake Regions** in Appendix B.*

♦ **Total nitrogen concentrations, like phosphorus concentrations, can vary seasonally in individual lakes.**

The variability in monthly total nitrogen concentrations is relatively low however, when compared to the amount of variation observed in algal levels and in total phosphorus concentrations in Florida lakes throughout a year. If there is a period when total nitrogen concentrations can be expected to be low, it generally occurs during the months of January and February. Maximum total nitrogen concentrations generally occur most frequently during the months of April, May, and October.

## Nitrogen As A Limiting Nutrient

Like phosphorus, nitrogen is an essential nutrient for all aquatic plants. In some cases, an inadequate supply of TN in waterbodies has been found to limit the growth of free-floating algae (i.e., phytoplankton). This is called **nitrogen limitation**, and occurs most commonly when the ratio of total nitrogen to total phosphorus is less than 10. In other words, the TN concentration divided by the TP concentration is less than 10 (TN/TP < 10).

☛ *For more information see **Determining the Limiting Nutrient In A Waterbody** on pages 11-16 and **Part 4 Limiting Environmental Factors Other Than Nutrients** on page 23.*

*Photo courtesy of Central Florida Visitors and Convention Bureau*

*Sunset fishing for bass on Lake Elbert in Winter Haven.*

### HEALTH CONCERNS

Like many people throughout the world, Floridians are concerned about water quality. Water quality is sometimes defined in terms of human health effects and toxicity to aquatic organisms. With regard to nitrogen, total nitrogen in surface waters does not reach high enough levels to pose a direct threat to human health. The maximum allowable level of nitrate, a component of the total nitrogen measurement, is 10 mg/L in drinking water. Generally, concentrations of nitrates in surface waterbodies do not reach this level because nitrates are readily taken up by plants and used as nutrients. Most forms of nitrogen are harmless to fish and aquatic organisms except unionized ammonia and nitrite, which can be toxic.

However, nitrites are usually not a problem in waterbodies; if there is enough oxygen available in the water, nitrites oxidize and are readily converted to nitrates.

## Total Nitrogen and Trophic State

When ONLY the average concentrations of total nitrogen (TN) from the Florida LAKEWATCH database are used, Florida lakes were found to be distributed into the four trophic states as described below.[6]

♦ Approximately 14% of the lakes (those with TN values less than 400 µg/L) would be classified as **oligotrophic**. *Oligotrophic lakes have very low levels of biological productivity.*
♦ About 25% of the lakes (those with TN values between 401 and 600 µg/L) would be classified as **mesotrophic**. *Mesotrophic lakes have moderate levels of biological productivity.*
♦ 50% of the lakes (those with TN values between 601 and 1500 µg/L) would be classified as **eutrophic**. *Eutrophic lakes have moderately high levels of biological productivity.*
♦ Nearly 11% of the lakes (those with TN values greater than 1500 µg/L) would be classified as **hypereutrophic**. *Hypereutrophic lakes have very high levels of biological productivity.*

6 *This distribution of trophic state is based solely on total nitrogen values without utilizing information on total phosphorus concentrations, chlorophyll concentrations, Secchi depth, or aquatic plant abundance.*

# Determining The Limiting Nutrient In A Waterbody

Aquatic scientists routinely recommend nutrient (phosphorus and nitrogen) control to manipulate algae populations in a waterbody. Controlling nutrients, as a way of manipulating algae, is one strategy for managing fisheries, water clarity, and wildlife populations. This strategy, however, only works if phosphorus and/or nitrogen are the environmental factors limiting algal abundance.

If nutrients are the environmental factors limiting algal abundance, you may be able to achieve overall management goals through nutrient control.[7] However, there are many methods for managing the growth of algae in waterbodies and the appropriate method of nutrient control is often debated at length. This debate can often be sidetracked by discussions over which nutrient, phosphorus or nitrogen, is limiting.

**If nutrients, rather than some other environmental factor, are limiting the growth of algae in a waterbody, there are a few possibilities that deserve consideration.**

If nutrients, rather than some other environmental factor, are limiting the growth of algae in a waterbody, there are a few possibilities that deserve consideration:

### ♦ Phosphorus and/or Nitrogen Is The Limiting Nutrient

There are two approaches that can be used to help you and/or a water manager decide whether:

- ♦ *phosphorus* is the limiting nutrient,
- ♦ *nitrogen* is the limiting nutrient, or
- ♦ *both* phosphorus and nitrogen are limiting nutrients in a waterbody.

One involves the use of a **TN/TP Ratio** (total nitrogen/total phosphorus ratio) and the other involves the use of **Phosphorus Threshold Value**.

☞ *See pages 13-16 for more on how **TN/TP ratios** and **Phosphorus Threshold Values** can be used to determine limiting nutrients in waterbody.*

### ♦ Some Nutrient Other Than Phosphorus Or Nitrogen Is the Limiting Nutrient

As mentioned earlier in this circular, nutrients like silica can be limiting in some Florida waterbodies. In addition, micronutrients[8] that are also necessary for the growth of plants and algae (such as molybdenum and zinc), may be in limited supply in some circumstances. Tests to evaluate these substances as potential limiting nutrients are sometimes recommended. The tests are relatively expensive, so they should only be considered if phosphorus and nitrogen are eliminated as possibilities.

In addition, nutrients are not always the limiting factor. Other environmental factors such as highly colored water can also influence the abundance of algae in a waterbody.

☞ *For more on limiting environmental factors see **Part 4 Limiting Environmental Factors Other Than Nutrients** on pages 23 and 24.*

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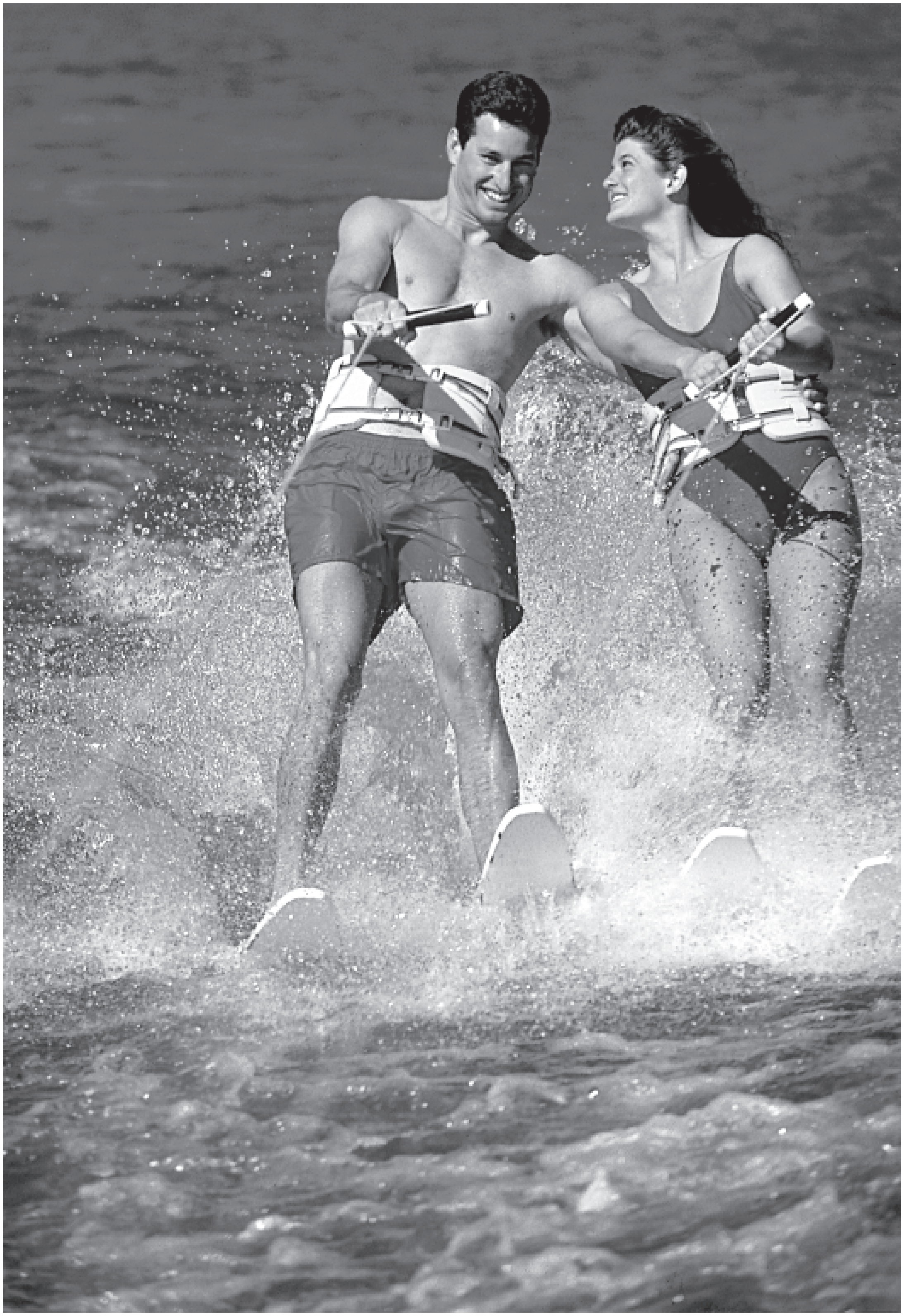
**7** *If you have not developed a management plan yet, you may want to read the booklet **How To Create a Lake Management Plan** by Jess VanDyke, Northwest Florida Regional Biologist, Department of Environmental Protection/Bureau of Aquatic and Invasive Plant Management. Free copies are available from Florida LAKEWATCH.*

**8** *The term **micronutrient** indicates that plants and algae need only tiny amounts of this nutrient. Contrary to its name, a micronutrient is of no smaller importance than a nutrient.*



Cypress Gardens, Florida

Photo courtesy of Central Florida Visitors and Convention Bureau

# Using A TN/TP Ratio To Determine Whether Phosphorus and / or Nitrogen Is The Limiting Nutrient

**Calculating a relatively simple ratio can sometimes provide a useful clue as to the relative importance of nitrogen or phosphorus toward the abundance of algae in a waterbody. Studies of Florida lakes have shown that the ratio of total nitrogen to total phosphorus (TN/TP) may indicate which nutrient plays the most significant limiting role.**

**By calculating TN/TP ratios for 534 Florida lakes...**

and plotting them on a scatter plot graph, a useful relationship emerges.

The scatter plot graph shown here (see Figure 2), illustrates that based on the relationship between total chlorophyll, total phosphorus values, and TN/TP ratios, Florida waterbodies can be loosely divided into three groups:

**Lakes with a TN/TP ratio less than 10** (represented by a △ in the graph)
**Lakes with a TN/TP ratio between 10 and 17** (represented with a ❍ in the graph)
**Lakes with a TN/TP ratio greater than 17** (represented with a ● in the graph)

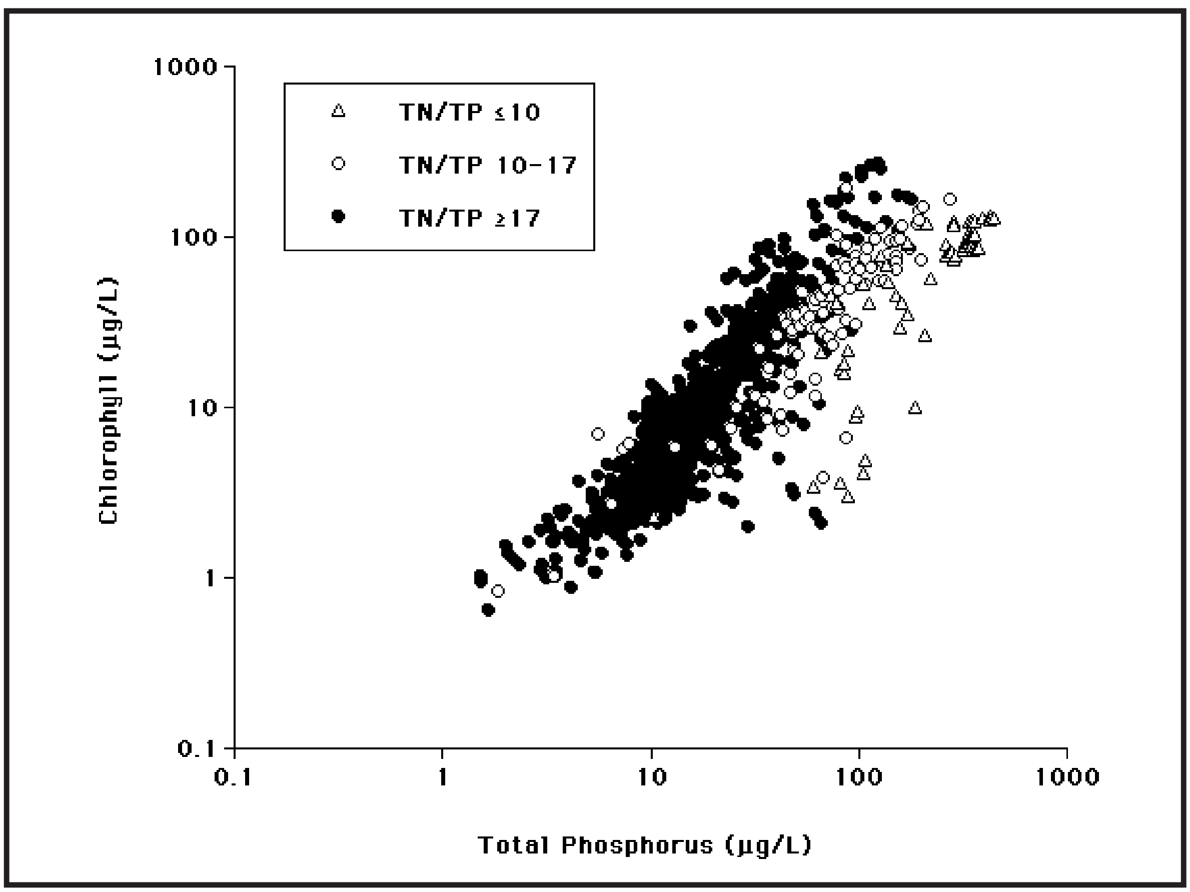



**Figure 2**. The relationship between total phosphorus concentrations and chlorophyll concentrations for Florida lakes.

**Lakes with a TN/TP ratio less than 10** (represented with a △ in the graph)

Notice that lakes in this group tend to be grouped in the upper right-hand corner of the graph, beyond where the 50 µg/L mark would be on the total phosphorus axis. Also notice that none of these lakes appear on the graph anywhere below the 50 µg/L mark on the total phosphorus axis. This can be interpreted to mean that phosphorus may not be the only factor affecting the growth of algae in these lakes.

**Lakes with a TN/TP ratio between 10 and 17** (represented with a ❍ in the graph)

Notice that, similar to the lowest TN/TP ratio group, this group of lakes also tends to be grouped in the upper right-hand corner of the scatter plot graph — with a few lakes scattered down toward the bottom left hand corner. Also, notice how many of lakes with higher TN/TP ratios (greater than 17 and represented by ●), have higher chlorophyll levels than lakes with the same amount of phosphorus (lakes represented by the △ and the ❍).

This can be interpreted to mean that a specific amount of phosphorus in the △ or ❍ lakes will not produce as much algae as that same amount of phosphorus in lakes with a TN/TP ratio greater than 17 (● lakes). Something is limiting the growth of algae (chlorophyll) in these lakes. However, it's unclear as to whether it's nitrogen or phosphorus.

**Lakes with a TN/TP ratio greater than 17** (represented with a ● in the graph)

The broad range of the black dots on graph can be interpreted to mean that lakes with the highest TN/TP ratio (greater than 17) generally have more chlorophyll per unit of phosphorus than lakes with lower TN/TP ratios. In other words, there seems to be a stronger correlation between phosphorus and chlorophyll in these lakes.

**In light of these observations, some scientists think that something other than phosphorus must be limiting the algal growth in the lower two TN/TP ratio groups** (the △ and ❍ lakes ) **— possibly nitrogen. Therefore, these scientists hypothesize:**

- when the TN/TP ratio is less than 10, a lake is nitrogen-limited;
- when the TN/TP ratio is between 10 and 17, there appears to be a gray area (nitrogen ***or*** phosphorus could be limiting);
- when the TN/TP ratio is greater than 17, a lake is phosphorus-limited.

Aquatic scientists have differing opinions as to whether 10 and 17 are the exact boundary values and whether this relationship applies to all waterbodies. Perhaps the TN/TP ratio can be useful in helping you decide whether nitrogen or phosphorus is the limiting nutrient in your waterbody.

## To calculate a TN/TP ratio...

Take the TN (total nitrogen) value and divide it by the TP (total phosphorus) value.

For example: If your lake's TN value is 300 and the TP value is 30, you'll need to divide 300 by 30 ... giving you a TN/TP ratio of 10.

**300 ÷ 30 = 10**

**NOTE:** *The TN and TP values you use to calculate this ratio can be from one day's water sample, or they can be attained by averaging a year's worth of monthly sample concentrations — called an annual mean.*

# Using a phosphorus threshold to determine whether phosphorus OR nitrogen is the limiting nutrient

## There appears to be two phosphorus thresholds in Florida lakes.

**1 In lakes with TP concentrations above 100 µg/L, there is the potential for nitrogen to be the limiting nutrient, rather than phosphorus. Why?**

It seems reasonable to assume that when the phosphorus concentration is high (e.g., above some threshold level), the probability that phosphorus will be the limiting nutrient decreases simply because of its abundance. Several observations support the idea that a phosphorus threshold of 100 µg/L separates Florida lakes that are phosphorus limited from those that are not. For example:

- Many lakes with total phosphorus concentrations exceeding 100 µg/L have TN/TP ratios that suggest they are not phosphorus limited (their TN/TP is generally less than 17, as shown in Figure 3 on page 16).
- Evidence from surveys of lakes suggests that concentrations of total phosphorus above a threshold value of 100 µg/L do not correspond to higher concentrations of chlorophyll.

**2 A second threshold of 50 µg/L is evident from Figure 3 on page 16.**

Lakes with a TN/TP ratio less than 10 (which suggests a nitrogen limitation) generally do not occur✪ when total phosphorus concentrations are less than 50 µg/L. This observation suggests that waterbodies with TP less than 50 µg/L are indeed most likely to be phosphorus limited.

✪ *There is one documented exception.*

***Check your Florida LAKEWATCH data to see if your waterbody falls into one of these categories. If so, phosphorus may NOT be a limiting nutrient.***

## Phosphorus control pitfall...

In nitrogen limited waterbodies, it may well be that both phosphorus and nitrogen need to be controlled simultaneously in order to manipulate chlorophyll concentrations. The TN/TP ratio offers a clue to understanding why. There is a positive relationship between phosphorus and chlorophyll in lakes with a TN/TP ratio less than 10, as shown in the upper graph in Figure 3 (page 16). This relationship suggests that by lowering the phosphorus concentration in one of these lakes, the chlorophyll concentration can be made to decrease.

This may be true — if the lake maintains a TN/TP less than 10. However, as TP is lowered, the TN/TP ratio will increase because its denominator is becoming smaller. If the TN/TP ratio becomes greater than 10, the chlorophyll concentration could actually stay the same, even though phosphorus has been reduced. Additional research is needed before phosphorus control techniques alone can be relied upon to reduce chlorophyll concentrations in lakes with high phosphorus concentrations (TP greater than 50 µg/L).

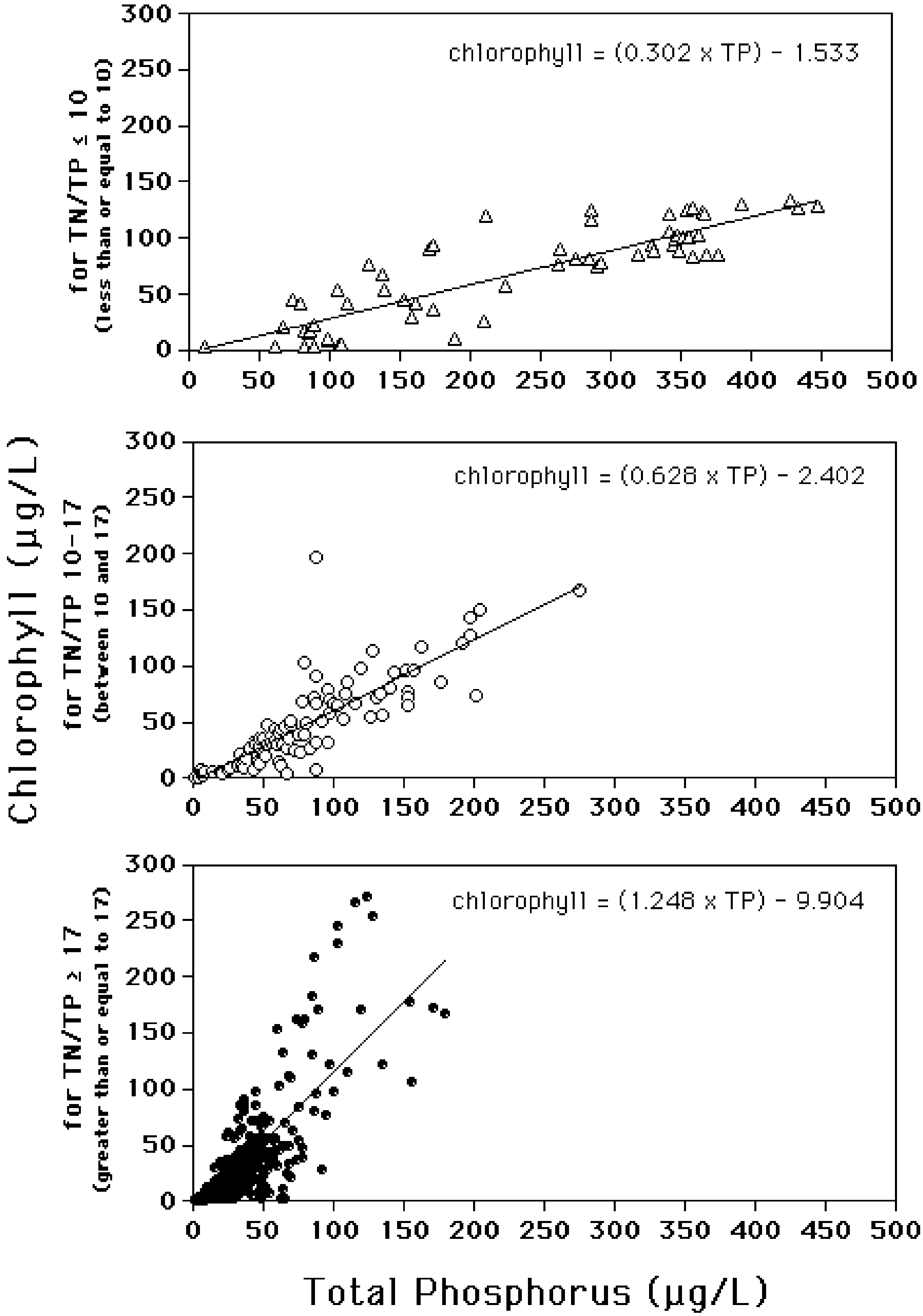



**Figure 3.** The relationship between total phosphorus concentrations and chlorophyll concentrations for Florida lakes with different total nitrogen to total phosphorus ratios.