

A Beginner's Guide to Water Management – The ABCs

Descriptions of Commonly Used Terms

Information Circular #101



UF/IFAS Communications

Florida LAKEWATCH

Department of Fisheries and Aquatic Sciences
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida

August 2000



Institute of Food and Agricultural Sciences



This publication was produced by

Florida LAKEWATCH

University of Florida/Institute of Food and Agricultural Sciences
Department of Fisheries and Aquatic Sciences
7922 NW 71st Street
PO Box 110600
Gainesville, FL 32611-0600

Phone: (352) 392-9617

Fax: (352) 392-3672

Citizen message line: 1-800-525-3928

E-mail: lakewat@ufl.edu

Web address: <http://www.ifas.ufl.edu/~lakewatch/index.htm>

Copies are available for download from the LAKEWATCH web site at:

<http://www.ifas.ufl.edu/~lakewatch/LWcirc.html>

Copyright © 2000

Limited reproduction of and/or quotation from this book is permitted, providing proper credit is given.

A Beginner's Guide to Water Management – The ABCs

Descriptions of Commonly Used Terms

Information Circular #101

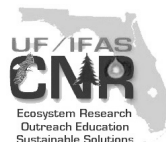
Florida LAKEWATCH

Department of Fisheries and Aquatic Sciences
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida

August 2000



Institute of Food and Agricultural Sciences



Prologue

One of the goals of the Florida LAKEWATCH Program is to bridge the information gap between the scientific community that studies Florida's waters and the people who want to learn about the lakes, rivers and streams they care for. The first step toward achieving this goal is to define a commonly understood language.

Language is a funny thing. Words can mean different things to different people — even when they are speaking the same language. From the lay public's viewpoint, scientific terminology might as well be a foreign language. Unfamiliar words may convey unintended meanings, or sometimes, no meaning at all. Even the most intelligent or well-educated listeners cannot be expected to translate a specialized scientific language without a guide, especially when the language is not part of their everyday experience.

This document is the first in a series of Information Circulars the LAKEWATCH Program is developing for the public. It is an introduction to the basic terminology and concepts used in the water management arena. Not all scientists and water managers may use the included terminology in precisely the same way. The descriptions used here represent water management as Florida LAKEWATCH professionals have come to understand it.



Amy Richard

Scientific Method

When faced with the task of explaining how things work in the physical world, scientists developed an investigative process called the **scientific method**. This system has been used for centuries and continues to be used today.

Ideally, the scientific method proceeds in stages. First, observations are made. These are considered to be facts. Then suppositions, called **hypotheses**, are made that seem to explain the cause-and-effect relationship among the facts. A hypothesis is a highly tentative statement — a hunch about how things work. Next, experiments are performed to test whether a hypothesis can correctly account for the experimental results that are observed.

During this stage, measurements called “data” are taken. If the data are consistent with the predictions made using the hypothesis, the hypothesis gains credibility. If not, the hypothesis is either discarded or modified. A hypothesis often goes through many revisions. After repeated experimental verifications, a hypothesis becomes a **theory**. The distinction between a hypothesis and a theory has become blurred in recent years.

A theory is not a tentative statement like a hypothesis — a theory has a high probability of being correct. For a theory to become accepted by the scientific community, there must be a consensus in the scientific community that a theory represents the truth.

The lay person should bear in mind that even though a scientific theory is believed to be credible by the scientific community, it could still be wrong.

Widely accepted theories are difficult to challenge, so they often persist. Scientists have been known to develop parental, protective attitudes toward their theories, sometimes defending them with a zeal that is far from objective.¹ Challengers face skepticism, even derision, which has often brought tragic personal consequences. History is replete with examples.

On the other hand, Nobel Prizes have been awarded to scientists who have had the courage and vision to contest popular theories in favor of new, more accurate ones.

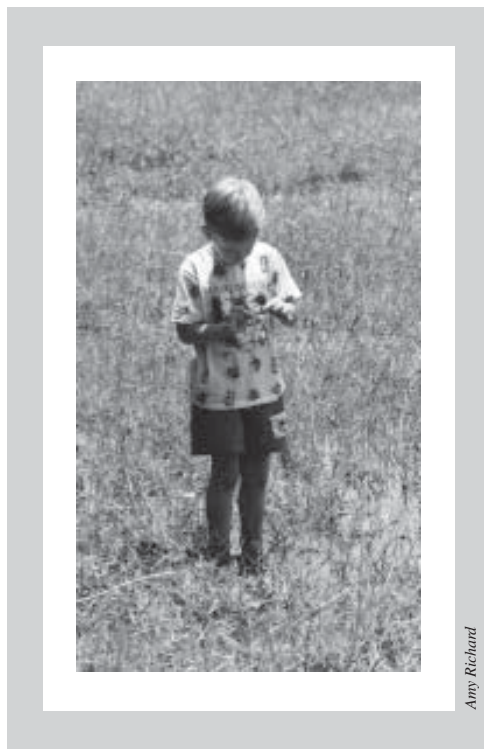
Using the scientific method can require many years of gathering and evaluating evidence, formulating and

reformulating hypotheses, and debating the value of competing theories. And even after all that, an accepted theory may eventually be proven false.

Unfortunately, developing reliable theories in the water management arena may take years, even centuries. In the meantime, understanding the speculative nature of the scientific method is important for both the lay public and professionals. Before anyone accepts a theory or a hypothesis, he or she should always find out what evidence supports it and whether there is any evidence that contradicts it.

In this way, hypotheses and widely-accepted theories can be put into proper perspective. Any hypothesis or theory is only as valid as the evaluative thought process that has produced it.

¹ Refer to Chamberlin's article "The Method of Multiple Working Hypotheses" (see references at the end of this circular).



Amy Richard

Metric to English Conversion Factors

To apply the scientific method properly, experiments must be performed during which measurements must be made. Every measurement consists of two parts: a number (how many?) and a unit of measure (i.e., pound, foot, second, etc.). For example, in the measurement 5.2 hours, the “5.2” tells how many, and “hours” is the unit of measure.

There are two primary systems used for making measurements: the metric system and the English system.

The United States is attempting to convert to the metric system, but acceptance by the general public has been slow. Because most scientific studies—including Florida LAKEWATCH research

—utilize the metric system, it will be used in this document. If you want to put a measurement into more familiar terms, you can calculate its English equivalent. Though converting is not necessary, it is helpful when trying to visualize quantities.

The following table shows common metric units and the conversion factors that can be used to calculate their equivalents in the corresponding English units. To convert a metric unit to an English unit, multiply the metric measurement by the conversion factor shown in the table. For example, multiply 5 meters times the conversion factor of 3.281 to get 16.405 feet — 5 meters and 16.405 feet are the same distance.

Metric Unit	Conversion Factor	English Unit
centimeter (cm)	0.3937	inch (in)
meter (m)	3.281	feet (ft)
kilometer (km)	0.6214	mile (mi)
square kilometer (km ²)	0.3861	square mile (mi ²)
hectare (ha)	2.471	acre (ac)
kilogram (kg)	2.205	pound (lb)
Liter (L or l)	1.057	U.S. quart (qt)
cubic meter (m ³)	264	U.S. gallon (gal)
milligrams/Liter (mg/L)	1.0	parts/million (ppm)
micrograms/Liter (µg/L)	1.0	parts/billion (ppb)
Celsius (C)	(C x 9/5) +32	Fahrenheit (F)

Metric Units

Converting from one unit of measure to another within the metric system is much easier than converting within the English system. The table below shows the most common conversion factors.

When you have an amount in these units:	Multiply by this number:	To get the equivalent in the units below:
milligrams (mg)	1000	micrograms (μg)
grams (g)	1000	milligrams (mg)
kilograms (kg)	1000	grams (g)
cubic meters (m ³)	1000	liters (L or l)
microgram per Liter ($\mu\text{g/L}$)	1	milligram per cubic meter (mg/m^3)

Note that the value of each metric conversion factor is indicated by the prefixes used:

milli means “one-thousandth,”
micro means “one-millionth,” and
kilo means “one thousand.”

Description of Terms Commonly Used in Water Management

Suggestions: The descriptions in this document will make more sense to you if you start by:

- 1) becoming familiar with the Measurement Units described on pages **iii** and **iv** so that metric units are not distracting to you when you encounter them in the text; and
- 2) reading the entries for **Algae**, **Aquatic Macrophytes**, **Biological Productivity**, and **Trophic State**. These particular entries will provide a background in the basic, often-used vocabulary and concepts.

Note: the ↗ symbol will be used to refer you to other relevant entries in this circular.

Algae

are a wide variety of tiny, often microscopic, plants (or plant-like organisms) that live both in water and on land. The word **algae** is plural (pronounced AL-jee), and **alga** is the singular form (pronounced AL-gah).

One common way to classify water-dwelling algae is based on where they live. Using this system, three types of algae are commonly defined as follows:

- ◆ **phytoplankton** (also known as planktonic algae) float freely in the water;
- ◆ **periphyton** are attached to aquatic vegetation or other structures; and
- ◆ **benthic algae** grow on the bottom or bottom sediments.

↗ See *Benthic, Periphyton, and Phytoplankton.*



Pediastrum

Photo by Mary Cichra

Algae may further be described as being **colonial** which means they grow together in colonies, or as being **filamentous** which means they form hair-like strands. The most common forms of algae are also described by their colors: green, blue-green, red, and yellow. All these classifications may be used together. For example, to describe blue-green, hair-like algae that are attached to an underwater rock, you could refer to them as “blue-green filamentous periphyton.”

In addition to describing types of algae, it is useful to measure quantity. The amount of algae in a waterbody is often called **algal biomass**. Scientists commonly make estimates of algal biomass based on two types of measurements:

- ◆ Because almost all algae contain chlorophyll (the green pigment found in plants), the concentration of chlorophyll in a water sample can be used to indicate the amount of algae present. This method, however, does not include all types of algae, only the phytoplankton. Chlorophyll concentrations are measured in units of **micrograms per Liter** (abbreviated $\mu\text{g/L}$) or in **milligrams per cubic meter** (abbreviated mg/m^3).

◆ In certain cases scientists prefer to count the individual algal cells or colonies in a sample and use their count to calculate the volume of the algae.

☛ See *Chlorophyll*.

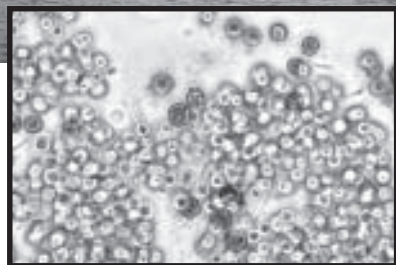
Some people consider algae to be unsightly, particularly when it is abundant. For instance, a phytoplankton bloom can make water appear so green that it's described as "pea soup."

In Florida, when chlorophyll concentrations reach a level over 40 µg/L, some scientists will call it an "algae bloom" or "algal bloom." The public, however, usually has a less scientific approach. They often define an algal bloom as whenever more algae can be seen in the water than they are accustomed to seeing (even though this may be a low concentration in some cases).



UF/IFAS Center for Aquatic and Invasive Plants

Algal blooms may be caused by human activities, or may be naturally



Mary Cichra

occurring. Sometimes, what seems to be an algal bloom is merely the result of wind blowing the algae into a cove or onto a downwind shore, concentrating it in a relatively small area, called a **windrow**.

The Role of Algae in Waterbodies:

Algae are essential to aquatic systems. As a vital part of the food web, algae provide the food necessary to support all aquatic animal life. Certain types of algae also provide habitat for aquatic organisms. On occasion, however, they can become troublesome and several examples are described as follows:

◆ An algal bloom can block sunlight, preventing the light from reaching the submersed aquatic plants below.

◆ Periphyton (filamentous algae) blooms and benthic algal blooms have the potential to interfere with other recreational uses like boating and fishing.

◆ An algal bloom can trigger a fish kill. In Florida, this is most likely to occur after several days of hot weather with overcast skies.

☛ See *Fish kill*.

Health Concerns:

Newspapers and magazines often present articles describing toxic algae. However, most algae are not toxic and pose little danger to humans. It should be remembered that toxic algae can be found in all aquatic environments.

Known health problems associated with algae have generally been associated with high concentrations of three species of blue-green algae:

- ◆ *Anabaena flos-aquae*,
- ◆ *Microcystis aeruginosa*, and
- ◆ *Aphanizomenon flos-aquae*.

With few exceptions, only fish and invertebrates have died from the effects of these toxic algae.

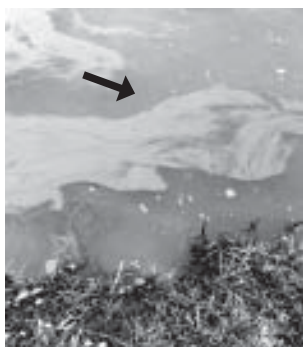
In Florida, it's extremely rare for algae to cause human illness or death. People are more likely to suffer minor symptoms such as itching. Several species of algae produce gases that have annoying or offensive odors, often a musty smell. These odiferous gases may cause health problems for some individuals who have breathing difficulties.

To be prudent, people should inform their doctor if they live near or use a waterbody often. This has become more important recently as the alga *Pfiesteria* has been known to cause severe health problems. (*Pfiesteria* tends to be found primarily in tidal waters.)

And while prudence is the watchword when using any waterbody, it must be recognized that people face greater health risks driving home from the grocery store than from *Pfiesteria* or any other toxic algae.

Algae bloom (or algal bloom)

In Florida, when chlorophyll concentrations reach a level over 40 µg/L, some scientists will call it an “algae bloom” or “algal bloom.”



Chuck Cichra

☞ See *Algae*.

Algal biomass

is the amount of algae in a waterbody at a given time. In this document, all estimates of the amount of algal biomass in a waterbody will be based on chlorophyll measurements.

☞ See *Algae*.

Alkalinity

refers to water’s ability, or inability, to neutralize acids. The terms **alkalinity** and **total alkalinity** are often used to define the same thing.

☞ See *Total alkalinity*.

Aquatic macrophytes

are aquatic plants that are large enough to be apparent to the naked eye; in other words, they are larger than most algae. The general term “aquatic plants” usually refers to aquatic macrophytes, but some scientists use it to mean both aquatic macrophytes and algae. (Note: Large algae such as *Cladophora*, *Lyngbya*, and *Chara* are also included in the category of aquatic macrophytes.)

Aquatic macrophytes characteristically grow in water or in wet areas and are quite a diverse group. For example, some are rooted in the bottom sediments, while others float on the water’s surface and are not rooted to the bottom. Aquatic macrophytes may be native to an area, or they may have been imported (referred to as *exotic*).

Most aquatic macrophytes are vascular plants, meaning they contain a system of fluid-conducting tubes, much like human blood

vessels. Cattails, waterlilies, and hydrilla are examples.

☞ See *Emergent plants, Floating-leaved plants, and Submersed plants*.

Even though they are quite diverse, aquatic macrophytes have been grouped into three general categories:

- ◆ **emergent** aquatic plants are rooted in the bottom sediments and protrude up above the water’s surface;
- ◆ **submersed** aquatic plants primarily grow completely below the water’s surface;
- ◆ **floating-leaved** aquatic plants can be rooted to the waterbody’s bottom sediments and also have leaves that float on the water’s surface. Examples are waterlilies, spatterdock and watershield;
- ◆ **free-floating** plants are a diverse group that float on or just under the water surface; they are not rooted to the bottom. Examples include tiny duckweeds and water fern as well as larger plants such as water hyacinth.



Joe Richard

In the eye of the beholder...

An aquatic weed problem is often defined differently by people who use a waterbody in different ways. For instance, for an angler a weed problem may be where aquatic macrophytes block boat access and snag fishing lines. However, for an industry manager, it may be where aquatic macrophytes clog cooling-water intakes or interfere with commercial navigation.

Aquatic macrophytes are a natural part of waterbodies, although in some circumstances they can be troublesome. The same plant may be a “desirable aquatic plant” in one location and a “nuisance weed” in another. When exotic aquatic plants have no natural enemies in their adopted area, they can grow unchecked and may become overly abundant.

In Florida for example, millions of dollars are spent each year to control two particularly aggressive and fast-growing aquatic macrophytes — water hyacinth, an exotic aquatic plant that is thought to be from Central and South America, and hydrilla, an exotic aquatic plant that is thought to be from Africa. The term “weed” is not reserved for exotic aquatic plants. In some circumstances, our native aquatic plants can also cause serious problems.

When assessing the abundance of aquatic plants in a waterbody, scientists may choose to measure or calculate one or more of the following:

- ◆ **PVI** (Percent Volume *Infested* or Percent Volume *Inhabited*) is a measure of the percentage of a waterbody’s volume that contains aquatic plants;
- ◆ **PAC** (Percent Area Covered) is a measure of the percentage of a waterbody’s bottom area that has aquatic plants growing on or over it;
- ◆ **frequency of occurrence** is an estimate of the abundance of specific aquatic plants; and
- ◆ **average plant biomass** is the average weight of several samples of fresh, live aquatic plants growing in one square meter of a lake’s area.

☞ See *Average plant biomass, Frequency of occurrence, PAC, and PVI.*

The Role of Aquatic Macrophytes in Waterbodies:

Aquatic macrophytes perform several functions in waterbodies, which are often quite complex. A few are briefly described below.

- ◆ Aquatic macrophytes provide habitat for fish, wildlife, and other aquatic animals.
- ◆ Aquatic macrophytes provide habitat and food for organisms that fish and wildlife feed on.

An unexpected result....

During their lifetime, aquatic plants slough off dead leaves and other plant parts that sink to the bottom. In this way, they contribute continually to the formation of sediments. A study of water hyacinths has shown that amount of sediment they contributed when a herbicide was used to kill them all at once was less than it would have been if the plants had been allowed to live out their full lifetimes.



Water hyacinth (*Eichhornia crassipes*)

- ◆ Aquatic macrophytes along a shoreline can protect the land from erosion caused by waves and wind.
- ◆ Aquatic macrophytes can stabilize bottom sediments by reducing the effects of wave action.
- ◆ The mixing of air into the water that takes place at the water’s surface can be obstructed by the presence of floating plants and floating-leaved plants. In this way, they can cause lower oxygen levels in the water.
- ◆ Free-floating plants and floating-leaved plants create shade that can cause the growth of submersed plants beneath them to be slowed or stopped.
- ◆ When submersed aquatic plants become more abundant, these plants can cause water to become clearer. Conversely, the removal or decline of large amounts of submersed aquatic plants can cause water to become less clear.
- ◆ When aquatic macrophytes die, the underwater decay process uses oxygen from the water. If massive amounts of plants die, it can result in severe oxygen depletion in the water, which can in turn cause fish and invertebrates to die from low oxygen.
- ◆ Decayed plant debris (dead leaves, etc.) contributes to the buildup of sediments on the bottom.

☞ See *Algae, Fish kill, and Water clarity.*

Aquatic plant

☛ See *Aquatic macrophytes and Algae*.

Average plant biomass

(as measured by Florida LAKEWATCH) is the average weight of several samples of fresh, live aquatic plants growing in one square meter of a lake's area. This measurement is taken separately for each category of plants: submersed, floating-leaved, and emersed. Measurements of average plant biomass are commonly used to help assess a waterbody's overall biological productivity and to assess the abundance of the different categories of aquatic plants present in a waterbody.

☛ See *Biological productivity*.

When LAKEWATCH staff measure aquatic plant biomass, they use the following procedure:

- ◆ Between 10 and 30 evenly-spaced sampling locations are chosen around the waterbody;
- ◆ At each sampling location, sampling is performed in three zones — the emergent plant zone, the submersed plant zone, and the floating-leaved plant zone;
- ◆ At each site, a square frame (one-quarter of a square meter in area) is tossed into the water and all above-ground aquatic plant material that falls inside the frame is harvested;
- ◆ Harvested plants are whirled around in a net bag to spin off excess water. The plants are then weighed on a scale that measures kilograms or grams;
- ◆ To calculate the biomass that would be in one square meter, the weight is multiplied times 4; and
- ◆ Values from all the sites for each category of aquatic plants are averaged separately.

The recorded weights are referred to as **wet weights**, because the plants are not allowed to dry out internally (like dried flowers). Plant biomass is also referred to as **fresh plant weight** and is reported by Florida LAKEWATCH in units of kilograms wet weight per square meter (abbreviated **kg wet wt/m²**).



Emergent plants are collected to calculate "average plant biomass."



Amy Richard



Joe Richard



Amy Richard

Submersed plants (above) and floating-leaved plants (left) are collected. Once collected they are spun to shake off excess water before being weighed.



Some professionals weigh plants that have been allowed to dry internally. Others include the weight of plant roots in their biomass measurement. LAKEWATCH only uses the wet weight of above-ground plant biomass because no expensive equipment is required and the results are just as useful for LAKEWATCH purposes.

Bathymetric map

a depth contour map depicting the surface area of a lake and water depths at regular intervals.



Benthic

is an adjective describing objects/organisms related to or occurring in or on bottom sediments of a waterbody.

Benthic algae

are algae that grow on the bottom sediments of a waterbody. Benthic algae are most commonly filamentous or colonial forms, but also may be microscopic single-celled organisms.

Benthic algae perform various beneficial functions in waterbodies, but may also be troublesome. Several examples of problems associated with benthic algae are described below:

- ◆ Benthic algal growth can snag anglers' fishing gear.
- ◆ Dense benthic growth can break free of the bottom and float to the surface.
- ◆ Large rafts of free-floating algae may form obstructive mats that can accumulate along shorelines.
- ◆ Offensive odors can be produced when benthic algae mats decompose.

☞ *See Algae.*

The Role of Benthic Algae in Waterbodies:

Benthic algae provide food and habitat for many aquatic organisms. In this way they contribute to the biological productivity of aquatic systems.

☞ *See Biological productivity.*

Health Concerns:

Benthic algae generally do not pose a known direct threat to human health.

Biological productivity

is defined *conceptually* as the ability of a waterbody to support life (such as plants, fish, and wildlife). Biological productivity is defined *scientifically* as the rate at which organic matter is produced. Measuring this rate directly for an entire waterbody is difficult and prohibitively expensive by most standards.

For this reason, many scientists base estimates of biological productivity on one or more quantities that are more readily measured. These include measurements of concentrations of nutrients in water, concentrations of chlorophyll in the water, aquatic plant abundance, and/or water clarity. The level of biological productivity in a waterbody is used to determine its trophic state classification.

☞ *See Aquatic plants, Chlorophyll, Nutrients, Trophic state, and Water clarity.*

Biomass

is the amount of living matter (as in a unit area or volume of habitat).

☞ *See Algae and Average plant biomass.*

Calcium

is a mineral that dissolves easily in water. Calcium is represented in the Periodic Table of Elements as **Ca**. It is one of the most abundant substances in both surface waters and ground waters.

Freshwaters around the world have higher concentrations of calcium when they are located closer to calcium-rich soils and rocks. Typical calcium concentrations worldwide are less than 15 mg/L, but waters close to calcium-rich carbonate rocks often have calcium concentrations exceeding 30 mg/L.

Calcium enters aquatic environments primarily through the weathering of rocks such as limestone, which is largely composed of calcium compounds. In some circumstances, calcium can also be deposited in waterbodies as a result of human activities, often because of the extensive use of calcium-containing chemicals in agriculture and industry.

Having calcium in your water supply may cause inconveniences. For example, you may have experienced difficulties in getting soap to lather in what is called “hard” water. In hard water, calcium will combine with soap molecules and inhibit their foaming ability. High concentrations of calcium can also cause a crusty accumulation called “scale” to form in pipes and hot water heaters. To prevent problems with hard water and scale formation, many cities soften water by removing calcium from their drinking water supply.

The Role of Calcium in Waterbodies:

Calcium has been shown to influence the growth of freshwater plants and animals. It is a necessary structural component of plant tissues, animal bones, and animal shells. Calcium is involved in many chemical cycles that occur in waterbodies, often in rather complex ways. For example, adding calcium carbonate to a waterbody can either stimulate aquatic plant growth or inhibit it.

Example 1 — when calcium carbonate, in the form of lime, is added to an acidic waterbody:

- ◆ the lime will cause the water to become less acidic (the pH will become higher);
- ◆ as the water becomes less acidic, phosphorus, a necessary nutrient, will be converted to forms that can then be used by aquatic plants, potentially stimulating their growth.

Example 2 — when a waterbody is not acidic (with a pH above 8.2) and contains an abundance of calcium carbonate :

- ◆ calcium carbonate will combine with the phosphorus in the water to form a solid called a “precipitate” that can sink to the bottom or be attached to aquatic plants;
- ◆ plants and algae will be deprived of phosphorus and their growth can be slowed.

☞ *See Limiting environmental factors, pH and Total phosphorus.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average calcium concentrations ranging from 0.2 to 94 mg/L. Over 75% of these waterbodies had calcium concentrations less than 16 mg/L.

Health Concerns:

Calcium in waterbodies is not known to have any severe effects on human health. Drinking large amounts of hard water when the body is accustomed to soft water, however, may have a laxative effect.

Chloride

is a substance found in all the world’s waters. Chloride is an ionized form of the element chlorine. It is represented in the Periodic Table of Elements as **Cl**. The symbol for the chloride ion is **Cl⁻**.

Chloride compounds are used extensively in industrial operations and agriculture. For example, the potash in fertilizer is potassium chloride. Common table salt is sodium chloride and is a necessary part of human and animal diets.

Chloride levels in waterbodies are affected by several factors. Climate is a major influence. For example, chloride concentrations in waterbodies in humid regions tend to be low, whereas those in semi-arid and arid regions may be hundreds of times higher because of higher rates of evaporation. Seawater often has a reported chloride concentration exceeding 15,000 mg/L, but the chloride levels vary considerably worldwide.

The activities of people and animals can also affect chloride concentrations. For example, because chloride is found in all animal and human wastes, septic systems and areas where animal wastes are deposited may be sources of chlorides in waterbodies. Home water softening systems and fertilizers also are sources of chlorides. For these reasons, the presence of chlorides can sometimes be used as an indicator of pollution from these sources.

The Role of Chlorides in Waterbodies:

Salts are the primary sources of chloride in water. (The term “salt” includes compounds in addition to sodium chloride.) Traveling by many pathways, chloride has found its way into all the world’s waters. Many coastal waters have high concentrations of chloride, because they are close to marine (i.e., saltwater) systems. In these waterbodies,



seawater can seep underground, called saltwater intrusion, or flow directly into them through tidal flow, for instance. Also, sea spray carries chloride into the air where it can then enter waterbodies as part of rainfall, even far from coastal areas.

The saltiness, or chloride concentration, of water can affect plants and wildlife. For example, some species die in water that is too salty, and others die in water that is not salty enough.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average chloride concentrations ranging from 1.7 to 2300 mg/L. Over 75% of these waterbodies had chloride concentrations less than 22 mg/L.

Health Concerns:

Chloride concentrations in lakes are generally so low that they pose no known threat to human health. Water will have a strong salty taste if chloride concentrations exceed 250 mg/L.

It should be noted that although the chlorides are not dangerous themselves, they signal the possibility of contamination from human or animal wastes that can contain bacteria and other harmful substances. For this reason, it is prudent to investigate where the chlorides are coming from when high concentrations are detected in an inland waterbody.

Chlorophyll

is the green pigment found in plants and found abundantly in nearly all algae. Chlorophyll allows plants and algae to use sunlight in the process of photosynthesis for growth. Thanks to chlorophyll, plants are able to provide food and oxygen for the majority of animal life on earth.

Scientists may refer to **chlorophyll a**, which is one type of chlorophyll, as are **chlorophyll b** and **chlorophyll c**. Measurements of **total chlorophyll** include all types. Chlorophyll can be abbreviated **CHL**, and total chlorophyll can be abbreviated **TCHL**.



LAKEWATCH volunteers filter lake water monthly to collect chlorophyll samples.

The Role of Chlorophyll in Waterbodies:

Measurements of chlorophyll concentrations in water samples are very useful to scientists. For example, they are often used to estimate algal biomass in a waterbody and to assess a waterbody's biological productivity.

☞ See *Algae, Algal biomass, Biological productivity, and Phytoplankton.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average chlorophyll concentrations ranging from less than 1 to over 400 µg/L. Using average chlorophyll concentrations from this same database, Florida lakes were found to be distributed into the four trophic states as follows:²

- ◆ 12% of the lakes (those with chlorophyll values less than 3 µg/L) would be classified as **oligotrophic**;
- ◆ about 31% of the lakes (those with chlorophyll values between 4 and 7 µg/L) would be classified as **mesotrophic**;
- ◆ 41% of the lakes (those with chlorophyll values between 8 and 40 µg/L) would be classified as **eutrophic**; and
- ◆ nearly 16% of the lakes (those with chlorophyll values greater than 40 µg/L) would be classified as **hypereutrophic**.

☞ See *Trophic state and each of its categories: Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic.*

In Florida, characteristics of a lake's geographic region can provide insight into how much chlorophyll may be expected for lakes in that area. For example, water entering the waterbodies by stream flow or underground flowage through fertile soils can pick up nutrients that can then fertilize the growth of algae and aquatic plants. In this way, the geology and physiography of a watershed can significantly influence a waterbody's biological productivity.

☞ See *Lake region.*

² This distribution of trophic state is based solely on chlorophyll values without utilizing information on nutrient concentrations or water clarity.

Health Concerns:

Chlorophyll poses no known direct threat to human health. There are some rare cases where algae can become high enough in abundance to cause concern. However, toxic algae are generally not a problem.

☛ *See Algae.*

Color

in waterbodies has two components:

- (1) **apparent color** is the color of a water sample that *has not* had particulates filtered out;
- (2) **true color** is the color of a water sample that *has* had all particulates filtered out of the water.



Milt Putnam, UF/IFAS Communications

The measurement of true color is the one most commonly used by scientists. To measure true color, the color of the filtered water sample is matched to one from a spectrum of standard colors. Each of the standard colors has been assigned a number on a scale of **platinum-cobalt units** (abbreviated as either **PCU** or **Pt-Co units**). On the PCU scale, a higher value of true color represents water that is darker in color.

The Role of Color in Waterbodies:

Dissolved organic materials (humic acids from decaying leaves), and dissolved minerals can give water a reddish brown “tea” color.

The presence of color can reduce both the quantity and quality of light penetrating into the water column. As a result, high color concentrations (greater than 50 PCU) may limit both the quantity and types of algae growing in a waterbody. Changing the quantity and quality of light reaching the bottom of a waterbody can also influence the depth of colonization and the types of aquatic plants that can grow there. In some waterbodies, color is the **limiting environmental factor**.

☛ *See Humic acids, Limiting environmental factor, and Water clarity.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average color values ranging from 0 to over 700 PCU. Over 75% of these waterbodies had color values less than 70 PCU.

Waterbodies that adjoin poorly drained areas (such as swamps) often have darker water, especially after a rainfall. Consequently, the location of a waterbody has a strong influence on its color. For example, lakes in the well-drained New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) tend to have color values below 10 PCU. While lakes in the poorly-drained Okefenokee Plains lake region in north Florida (in Baker, Columbia, and Hamilton Counties) tend to have values above 100 PCU.

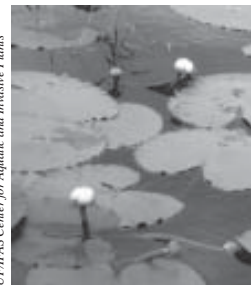
☛ *See Lake region.*

Health Concerns:

There is no known direct health hazard of color. Consequently, an acceptable level of color depends on personal preference. Water transparency, however, may be reduced in highly colored waters (greater than 50 PCU) to the point where underwater hazards may be concealed, creating a potentially dangerous situation for swimmers, skiers, and boaters.

Common plant name

Plants have scientific names and common names. For example, the floating aquatic plant known scientifically as *Nuphar luteum* is also



UF/IFAS Center for Aquatic and Invasive Plants

Spatterdock (*Nuphar luteum*)

known by several common names—**bonnet**, **cow lily** or **spatterdock**. It’s important to note that the common name may vary depending on which region of the state you might be in. Also, the same common name is sometimes even used for different plants. Scientists usually choose to identify plants by their scientific name, to eliminate this confusion.

☛ *See Plant species and Scientific plant name.*

Conductance (or Conductivity)

☞ *See Specific conductance.*

Emergent plants

are aquatic plants rooted in bottom sediments with leaves protruding above the water's surface. Cattail, maidencane, and bulrush are examples of emergent plants. Emergent plants grow in water-saturated soils and submersed soils near the edge of a waterbody. They generally grow out to a maximum depth of from 1 to 3 meters (about 3 to 10 feet). Emergent plants perform many functions in waterbodies:

- ◆ Emergent plants provide habitat for fish.
- ◆ Emergent plants provide food and habitat for wildlife populations such as ducks.
- ◆ Emergent plants reduce shoreline erosion.
- ◆ Emergent plants increase evapotranspirational³ water losses from a waterbody, sometimes to the point where water levels are lowered.
- ◆ Emergent plants shed leaves and other plant debris, adding to the bottom sediments and making the water shallower.
- ◆ As emergent plant debris accumulates in shallow water areas, shorelines migrate lakeward.
- ◆ Uprooted plants can form floating islands called **tussocks** that can be significant navigational hazards and block access to parts of the waterbody. It should be noted tussocks also provide bird and wildlife habitat.

Emergent plants react in various ways to changing water levels. When periods of low water are followed by a rapid rise in water level, large sections of emergent plants may be uprooted. Sustained high water can also reduce emergent



Annual Spikerush (*Eleocharis geniculata*)

UF/IFAS Center for Aquatic and Invasive Plants

plant abundance. In periods of low water, debris from emergent plants is a significant factor. Accumulated plant debris can eventually (i.e., 100-10,000 years) cause the lake to become more shallow, eventually forming a swamp or marsh, and ultimately, peat deposits.

☞ *See Aquatic macrophytes, Emergent plant biomass and Width of emergent and floating-leaved zone.*

In Florida:

Emergent plants occur naturally in all Florida waterbodies. The width of the emergent zone (from the shoreline out into the lake) may vary from a few meters to hundreds of meters. Its size changes most often in response to changing water levels. If emergent plants have been allowed to grow without human intervention, the lakeward edge of the emergent plants can be used to show where a waterbody's low water level has been in the past few years or perhaps even decades.

Health Concerns:

Emergent plants are not generally thought of as a cause of human health problems. However, dense growths of emergent plants provide habitat that can harbor disease-carrying mosquitoes.

Emergent plant biomass

(as used by Florida LAKEWATCH) is the average weight of fresh, live emergent aquatic plants growing in one square meter of a lake's bottom area. The measurement of average emergent plant biomass in a waterbody is one of several measurements that can be used to assess a waterbody's overall biological productivity.

☞ *See Average plant biomass and Biological productivity.*

In Florida:

Average emergent plant biomass in Florida lakes generally ranges from 0 to 27 kg wet wt/m². Emergent plant biomass appears to be linked with a waterbody's biological productivity. For example:

³ Evapotranspiration is different from evaporation. Evapotranspiration is the process in which water evaporates from the surface of plants or is emitted as a vapor from the surface of leaves or other plant parts.

- ◆ in biologically less productive lakes (oligotrophic lakes), the average emergent plant biomass is about 2.5 kg wet wt/m²;
- ◆ in moderately productive lakes (mesotrophic lakes), the average emergent plant biomass is about 3.0 kg wet wt/m²;
- ◆ in highly productive lakes (eutrophic lakes), the average emergent plant biomass is about 3.5 kg wet wt/m²; and
- ◆ in the most highly productive lakes (hypereutrophic lakes), the average emergent plant biomass is about 4.0 kg wet wt/m².

☞ See *Trophic state* and each of its categories: *Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic*.



Mark Hoyer

Eutrophic

is an adjective used to describe the level of biological productivity of a waterbody. Florida LAKE-WATCH and many professionals classify levels of biological productivity using four trophic state categories: **oligotrophic**, **mesotrophic**, **eutrophic**, and **hypereutrophic**. Of the four trophic state categories, the eutrophic state is defined as having a high level of biological productivity, second only to the hypereutrophic category. (The prefix “eu” means good or sufficient.)

A eutrophic waterbody is capable of producing and supporting an abundance of living organisms (plants, fish, and wildlife). Eutrophic waterbodies generally have the characteristics described below:

- ◆ Eutrophic lakes are more biologically productive than oligotrophic and mesotrophic lakes. Some of

Florida’s best fishing lakes are often eutrophic, supporting large populations of fish, including sportfish such as largemouth bass, speckled perch, and bream.

- ◆ Typically, eutrophic waters are characterized as having sufficient nutrient concentrations to support the abundant growth of algae and/or aquatic plants.
- ◆ When algae dominate a eutrophic waterbody, chlorophyll concentrations will be high — greater than 7 µg/L. The result will be less clear water; Secchi depth readings will be low (less than 8 feet).

In contrast, when aquatic plants dominate a eutrophic waterbody (instead of algae), chlorophyll concentrations and nutrient concentrations will be lower and the water will be clearer. Secchi depth readings will be greater (larger numbers) than they would be in eutrophic waterbodies with fewer plants.

Despite being classified as eutrophic, these plant-dominated waterbodies display the clear water, low chlorophyll concentrations, and low nutrient concentrations that are more characteristic of mesotrophic or oligotrophic waterbodies.

- ◆ Regardless of whether eutrophic waterbodies are plant-dominated or algae-dominated, they generally have a layer of sediment on the bottom resulting from the long-term accumulation of plant debris. In some eutrophic lakes, however, the action of wind and waves can create beaches or sandy-bottom areas in localized areas.

- ◆ Eutrophic waterbodies can have occasional algal blooms and fish kills. However, fish kills generally occur in hypereutrophic lakes when chlorophyll concentrations exceed 100 µg/L.

☞ See *Algae, Aquatic macrophytes, Chlorophyll, Fish kill, Hypereutrophic, Mesotrophic, Oligotrophic, Secchi depth, Trophic state, and Water clarity*.

Fish kill

is an event in which dead fish are observed. Some fish kills are extremely noticeable and may be viewed by the public as being damaging to the fish population. However, contrary to their appearance, typical fish kills in lakes only affect a small percentage of the fish

in a waterbody. Fish kills may occur for several reasons.

The most common cause of fish kills is related to the depletion of oxygen in shallow waterbodies. Oxygen depletion may be caused in various ways. Three of the most common are as follows:

1 Whenever aquatic organisms die, oxygen is pulled from the water column and is used in the decay process. Oxygen can become critically reduced in this way, especially in waterbodies that have an abundance of algae. For waterbodies in which the concentration of total chlorophyll exceeds 100 µg/L (indicating a high algae level), oxygen depletion is a likely cause of a fish kill. This is because the fraction of the algal population that is dying naturally is a large amount of mass; and therefore, its decomposition can consume significant amounts of oxygen.

2 Similarly, oxygen depletion can also occur when large amounts of aquatic plants die within a short time. Herbicide applicators commonly treat areas of aquatic plants at different times in order to avoid this situation, or they use herbicides that cause plants to die slowly.

3 A fish kill due to oxygen depletion can also be triggered by several days of overcast skies, especially during hot weather. This can happen because aquatic plants and algae add oxygen to water only when there is sufficient sunlight for photosynthesis; however, they consume oxygen all the time in their normal biological processes. When overcast skies persist for several days, oxygen levels can become depleted because the plants are using more oxygen than they are producing. Waters are particularly vulnerable when the temperature is high, because warmer water contains less oxygen to start with than cooler water. Fish “gulping” at the surface may be a sign of an oxygen problem.

Some species of fish die naturally in large numbers after spawning or when they are stressed by unusual or harsh weather conditions. High concentrations of hydrogen sulfide (perhaps from a sulfur-water spring or artesian well) may be the cause of a fish kill. In this case, sometimes a rotten egg smell is noticeable.

☛ See *Algae, Eutrophic, Hypereutrophic, Sulfur, and Total chlorophyll.*

Floating-leaved plants

are aquatic plants that are primarily rooted to bottom sediments and also have leaves that float on the water’s surface. (Note: Although usually not rooted on the bottom, free-floating plants such as water hyacinth and water lettuce are sometimes included in this plant classification.)

Waterlilies, spatterdock, and lotus are examples of floating-leaved plants. Floating-leaved plants are generally found growing along the shoreline, lakeward of the emergent plants. Floating-leaved plants perform many functions in waterbodies. Some of the most common are described below:

- ◆ According to many aquatic scientists, the primary role of floating-leaved plants in waterbodies is to provide food and habitat for wildlife and fish. Food for fish is provided principally when many varieties of small animals feed on the algae that have attached themselves to these plants.
- ◆ Floating-leaved plants can reduce shoreline erosion.
- ◆ Decaying material produced by floating-leaved plants accumulates in the sediments over many years (i.e., 100-10,000 years), playing an influential role in making a waterbody shallower.
- ◆ Debris from floating-leaved plants contributes to the formation of peat deposits, particularly as the lake becomes shallower over time and aquatic plants grow more abundantly.
- ◆ If periods of low water are followed by a rapid rise in water level, the roots of some dead floating-leaved plants (called rhizomes) can float to the surface where they block access and cause difficulties with navigation.
- ◆ In many cases, masses of rhizomes uprooted from the bottom can form floating islands called **tussocks**—becoming so large that trees can grow on them.
- ◆ In waterbodies where water hyacinths or water lettuce grow extremely well, these plants may completely cover the waterbody’s surface and cause major navigational problems.



Water shield (*Brasenia schreberi*)

☛ See *Aquatic macrophytes, Emergent plants, and Floating-leaved plant biomass.*

In Florida:

Floating-leaved plants occur in many Florida waterbodies. If the lake is shallow enough, rooted floating-leaved plants can grow completely across it. In Florida waterbodies where there are extensive loose sediments, the roots of floating-leaved plants anchored to the bottom provide a stable surface that some species of fish need for successful spawning.

The stems of floating-leaved plants (i.e. spatterdock) often contain burrowing insects called bonnet worms that some anglers use for bait. In many Florida waterbodies, certain floating-leaved plants are considered a major aquatic weed problem and require constant management in order to maintain acceptably low levels. For example, water hyacinths can grow so densely that waterways become impassable.

Health Concerns:

Floating-leaved plants are not generally thought of as a human health concern, although they can create problematic situations. For example, dense growths of floating-leaved plants can entangle swimmers. Floating-leaved plants may also provide habitat for mosquitoes and animals like snakes and alligators that may be dangerous under certain conditions.

Floating-leaved plant biomass

(as used by Florida LAKEWATCH) is the average weight of fresh, live floating-leaved plants growing in one square meter of a lake's bottom area. The measurement of floating-leaved plant biomass in a waterbody is one of several measurements that can be used to assess a waterbody's overall biological productivity.



Joe Richard

☛ See *Average plant biomass and Biological productivity.*

In Florida:

Average floating-leaved plant biomass in Florida lakes generally ranges from 0 to 19 kg wet wt/m². It appears to be linked with a waterbody's biological productivity. This relationship can be summarized as follows:

- ◆ in biologically unproductive (oligotrophic) lakes, the average floating-leaved plant biomass is about 1.0 kg wet wt/m²;
- ◆ in moderately productive (mesotrophic) lakes, the average floating-leaved plant biomass is about 1.5 kg wet wt/m²;
- ◆ in highly productive (eutrophic) lakes, the average floating-leaved plant biomass is about 2.0 kg wet wt/m²; and
- ◆ in the most highly productive (hypereutrophic) lakes, the average floating-leaved plant biomass is about 3.0 kg wet wt/m².

☛ See *Trophic state and each of its categories: Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic.*

Frequency of occurrence

(of an aquatic plant) is an estimate of the relative abundance of specific aquatic plants. Florida LAKEWATCH determines the frequency of occurrence using the following procedure:

- ◆ A number of evenly-spaced locations are chosen around a shore (usually 10 per lake, but up to 30 locations in a large lake). Locations are selected so that they will give a reasonable representation of the vegetation present in the waterbody.
- ◆ At each location, a visual inventory is performed in each of three areas — the emergent plant zone, the floating-leaved plant zone, and the submersed plant zone.
- ◆ The frequency of occurrence is the percentage of locations at which a particular plant was seen. For example, if ten locations were sampled and the plant maidencane was seen at four of them, the frequency of occurrence of maidencane would be 40% (that is, 4 divided by 10, then multiplied by 100%).

Fresh plant weight

is the weight of fresh, live plant material that has been collected from a waterbody and shaken or spun to remove excess water. These plants are considered to be *wet* because they are fresh and full of internal moisture. The unit of measure used by Florida LAKEWATCH is **kilograms wet weight per square meter** (abbreviated **kg wet wt/m²**).



Amy Richard

☛ See *Limiting environmental factors*.

Hypereutrophic

is an adjective used to describe the level of biological productivity of a waterbody. Florida LAKEWATCH and many professionals classify levels of biological productivity using four trophic state categories — **oligotrophic**, **mesotrophic**, **eutrophic**, and **hypereutrophic**. Of the four trophic state categories, the hypereutrophic state is defined as having the highest level of biological productivity. The prefix “hyper” means over abundant. Hypereutrophic waterbodies are among the most biologically productive in the world. Hypereutrophic waterbodies generally have the characteristics described below.

- ◆ Hypereutrophic waterbodies have extremely high nutrient concentrations.
- ◆ While hypereutrophic waterbodies can be dominated by non-sportfish species (gizzard shad and catfish), they can also support large numbers and large sizes of sportfish including largemouth bass, speckled perch, and bream.⁴
- ◆ A hypereutrophic waterbody has either an abundant population of algae or an abundant population of aquatic macrophytes. Sometimes it will support both.

◆ Hypereutrophic waterbodies **dominated by algae** are characterized by having high chlorophyll concentrations (greater than 40 µg/L). These waterbodies have reduced water clarity, causing Secchi depth readings to be less than 1 meter (about 3.3 feet). In contrast, when **aquatic macrophytes dominate** a hypereutrophic waterbody, chlorophyll concentrations will be lower. Secchi depth readings will be greater, mimicking those of less biologically productive waterbodies.

◆ Regardless of whether a waterbody is plant-dominated or algae-dominated, it will typically have thick sediments on the bottom as decaying plant and/or algal debris accumulates.

Geologic region

is an area with similar soils and underlying bedrock features. Characteristics of a waterbody’s geologic region may be responsible for its chemical characteristics and trophic state.

Geology can also have a significant influence on the shape of a waterbody’s basin — a factor that affects many of a waterbody’s features.

* See *Lake region, Morphometry, and Trophic state*.

Groundwater

is water that is underground. Groundwaters are distinguished from “surface waters” which are found on top of the ground. In Florida, groundwater resides at different depths in several regions called aquifers.

Humic acids

are produced when organic matter such as dead leaves decay. Humic acids can color water so that it appears reddish or reddish-brown, like tea. In some cases, the water can appear almost black.

☛ See *Color*.

Hydraulic flushing rate

is the rate at which water in a waterbody is replaced by new water.

⁴ Dominance of fish can be evaluated several ways — by measuring “numbers of fish per acre” and/or “weight of fish per acre.” Fish can also be sampled using one or more of a variety of catch methods. Each combination of measurement and sampling techniques may give different indications of which fish are dominant in a waterbody.



Joe Richard

Hypereutrophic lakes are often characterized as being “dead.” However, quite the reverse is true. To say that a waterbody is hypereutrophic implies it’s capable of producing and supporting the greatest abundance of living organisms such as plants, invertebrates, fish, and wildlife.

- ◆ Hypereutrophic waterbodies may experience frequent algal blooms.
- ◆ Oxygen depletion may also be a common cause of fish kills in these waterbodies.

☛ See *Algae, Aquatic macrophytes, Chlorophyll, Fish kill, Secchi depth, and Trophic state.*

Iron

is a common element found in the soils of the earth. Iron is abbreviated in the Periodic Table of Elements as **Fe**. Iron exists in either ferrous (Fe^{++}) or ferric (Fe^{+++}) forms.

The Role of Iron in Waterbodies:

Iron is an essential nutrient for aquatic plants and algae. In addition, iron performs an important function in aquatic systems through its interaction with another nutrient — phosphorus. Specifically, the presence of iron influences whether phosphorus is in a form that can be used by plants and algae. This relationship also depends on whether adequate oxygen is present.

Here’s how it works:

Example 1: when oxygen *is* present in sufficient amounts in the waterbody —

- ◆ iron will tend to bind with phosphorus;
- ◆ aquatic plants and algae cannot use phosphorus in this form;
- ◆ the result may be that the growth of aquatic plants and algae is limited.

Example 2: when oxygen is *not* present in sufficient amounts in the waterbody —

- ◆ iron-phosphorus compounds dissolve;
- ◆ aquatic plants and algae can use phosphorus in this dissolved form;
- ◆ the result may be that the growth of aquatic plants and algae is increased.

Waterbody managers may try aerating iron-rich waters as a strategy to reduce phosphorus concentrations in order to limit nuisance aquatic plant and algal growth, hoping for the results described in Example 1. This effort may be thwarted, however, if sulfur is plentiful in the water. Iron has the chemical characteristic of preferring to bind with sulfur instead of with phosphorus, when there is adequate oxygen present, as with an aerator. Therefore, in aerated sulfur-rich waters, phosphorus would still be available for aquatic plant and algae use, and the expected decline in aquatic plant and algal growth would not be realized.

An understanding of the role iron plays in the phosphorus cycle is a particularly important management tool in waterbodies where the primary supply of phosphorus is that which is dissolved from the bottom sediments into the water column. In this situation, iron manipulation is one of only a few management strategies that have the potential to limit phosphorus availability effectively.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average total iron concentrations ranging from 0 to 2.4 mg/L. Over 75% of these waterbodies had total iron concentrations less than 0.24 mg/L. The highest concentrations of iron are found in Florida’s highly colored waterbodies. This is

understandable because iron combines readily with organic molecules (like those that make water appear tea-colored), probably causing the water to become iron enriched.

☛ *See Color and Humic acids.*

Health Concerns:

Iron is not considered a known threat to human health. It may, however, be toxic to invertebrates and fish. Canada has issued a guideline stating that total iron should not exceed 0.3 mg/L, which is higher than the concentration found in most Florida lakes. If iron is a cause of toxicity to Florida's aquatic organisms, and there is no evidence that it is, only a few Florida lakes are potentially at risk.

Lake region

is a geographic area 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.

Lakes in an individual lake region exhibit remarkable similarities. However, lakes in one lake region may differ significantly from those in a different lake region. For example, most lakes in the New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) tend to have lower total nitrogen, lower total phosphorus, lower chlorophyll concentrations and higher Secchi depths

A copy of *Lake Regions of Florida* can be obtained by contacting the U.S. Environmental Protection Agency at 200 SW 35th Street, Corvallis, OR 97333 and requesting Publication EPA/R=97/127. A color poster of the Florida Lake Regions can be obtained from the Florida Department of Environmental Protection (Tallahassee phone: 850/921-9918). These sources are valid as of October, 1999.

when compared to other Florida lakes.

In contrast, lakes in the Lakeland/Bone Valley Upland lake region in central Florida (in Polk and Hillsborough Counties) tend to have higher total nitrogen, higher total phosphorus, higher chlorophyll concentrations and lower Secchi depths, when similarly compared.

Using descriptions of lake regions, reasonable, attainable water management goals and strategies can be established for individual lakes.

In addition, lakes with water chemistry that differs markedly from that of other lakes in the same lake region can be identified and investigated to determine the cause of their being atypical.

The lake regions are mapped and described in *Lake Regions of Florida* (EPA/R=97/127). The Florida LAKEWATCH Program can provide a free pamphlet describing:

- (1) how and why the lake regions project was developed;
- (2) how to compare your lake with others in its Lake Region; and
- (3) how the Lake Region Classification System can be useful to you.

Limiting environmental factors

are factors whose presence or absence causes the growth of aquatic plants and/or algae to be restricted. A few examples are described below.

◆ Suspended solids (tiny particles stirred up from bottom sediments or washed in from the watershed) can reach concentrations high enough that the growth of plants and algae is limited because sunlight is blocked out of the water column. This is a common situation in shallow lakes, especially those with heavy wave action like Lake Okeechobee in south Florida.

◆ The color of dissolved substances, though translucent, can block sunlight and retard algal growth. Many of Florida's lakes are tea-colored (reddish or reddish-brown) because of dissolved organic substances in the water. Even when tea-colored lakes are rich in nutrients, the growth of algae and submersed aquatic plants can be limited because the colored water prevents sunlight from reaching them.

◆ **Hydraulic flushing rate** is the rate at which water in a waterbody is replaced with new water. The flushing rate can influence algal abundance significantly. Waterbodies with high flushing rates — such as many of Florida’s springs — have low planktonic algal levels even though they may have high nutrient concentrations. This paradoxical condition exists because algae are flushed out of the system before they have time to grow to their maximum potential.

◆ **Aquatic macrophytes** should also be considered as a limiting environmental factor, because their presence may limit the growth of free-floating algae in Florida waterbodies indirectly. For example, if macrophyte coverage (PAC) is less than 30% of a waterbody, the presence of macrophytes does not appear to influence open-water algal levels. However, lakes with aquatic macrophytes covering over 50% of their bottom area typically have reduced algal levels and clearer water.

1 One explanation is that either aquatic macrophytes, or perhaps algae attached to them, use the available phosphorus in the water, competing with the free-floating algae for this necessary nutrient.

2 Another explanation is that macrophytes anchor the nutrient-rich bottom sediments in place and buffer the action of wind, waves, and human effects, preventing re-suspension of nutrients into the water column that can stimulate algal growth.

3 These same macrophytes act as a third type of buffer by preventing wind and wave action from re-suspending the actual algal cells (and/or other suspended solids) into the water column. By preventing algal cells from re-entering the water column, the macrophytes (plants) inhibit any further algal growth, due to the fact that the algal cells are “lost” in the bottom sediments where they are denied the necessary light and nutrients required for growth.

Often the management of a waterbody is focused solely on the manipulation of nutrients as a strategy for controlling growth of algae and/or plants. However, a truly skilled manager will evaluate all the potentially limiting environmental factors and consider every possibility.

☛ See *Algae, Aquatic macrophytes, Color, Humic acids, and Trophic state.*

Limiting nutrient

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

In Florida waterbodies, nitrogen and phosphorus are most often the limiting nutrients. Aquatic plants may not respond as directly to nutrient limitation in the water as do algae because many of these plants can also take their required nutrients from the bottom sediments, through their roots, as well as from the open-water.⁵

In most freshwater lakes in Florida, the limiting nutrient is believed to be phosphorus. However, in watersheds where soils contain sizeable deposits of phosphorus, nitrogen will usually be the limiting nutrient. Nitrogen may be the limiting nutrient in some saltwater systems. Less commonly, silica can be the limiting nutrient in some waters. Trace nutrients (like molybdenum and zinc) that are necessary for the growth of plants and algae may also be in limited supply in some circumstances.

☛ See *Limiting environmental factors, Nitrogen, Phosphorus, and Silica.*

Limnology

is the scientific study of the physical, chemical, and biological characteristics of inland (non-marine) aquatic systems. It is a multi-disciplinary science involving botany, chemistry, engineering, fisheries biology, and zoology to foster

a better understanding of freshwater systems.

A limnologist is a scientist who studies limnology.

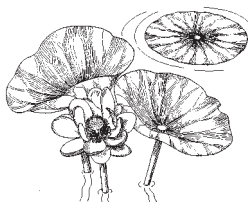
⁵ *Atlas of Alberta Lakes, 1990. University of Alberta Press, Edmonton, Canada.*



Joe Richard

Macrophyte

☞ See *Aquatic macrophytes*.



Magnesium

is the eighth most abundant natural element on earth and is a common component of water. Magnesium is found in many geologic formations, including dolomite. It's an essential nutrient for all organisms and is found in high concentrations in vegetables, algae, fish, and mammals. Magnesium is represented in the Periodic Table of Elements as **Mg**.

The Role of Magnesium in Waterbodies:

Natural sources contribute more magnesium to the environment than do all human activities combined. Magnesium is found in algal pigments (known as chlorophyll) and is used in the metabolism of plants, algae, fungi, and bacteria. Freshwater organisms need very little magnesium compared to the amount available to them in water. Because there is such little biological demand for magnesium compounds and because they are highly soluble, magnesium concentrations in waterbodies fluctuate very little.

Elevated (high) magnesium concentrations, can cause water to be designated as “hard” water. (Elevated calcium concentrations can have the same affect.) When hard water is used for agricultural, domestic, and industrial purposes, a crusty mineral buildup called “scale” can form and cause problems. The scale produced by extremely hard water can clog irrigation lines and water pipes in houses and can reduce the efficiency of hot water heaters.

☞ See *Calcium* (for a description of hard water).

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998, had average magnesium concentrations ranging from 0.2 to over 600 mg/L. Magnesium concentrations are higher in waterbodies where inflowing water has been in contact with dolomite.

Health Concerns:

Magnesium causes no known human health problems. Drinking large amounts of hard water when the body is accustomed to soft water, however, may have a laxative effect.

Mean depth

is another way of saying “average water depth.” The mean water depth is measured in either feet or meters and is designated in scientific publications by the letter “z.”

Mean depth can be estimated by measuring the water depth in many locations and averaging those values. Individual depth measurements may be done by using a depth finder (fathometer) or by lowering a weight, at the end of a string or rope, into the water and measuring how far it sinks below the surface until it rests on the bottom.

If more accuracy is needed, mean depth should be calculated by dividing a waterbody's volume by its surface area. This method will usually result in a different value than if measured depths are averaged.

☞ See *Water depth*.

Mesotrophic

is an adjective used to describe the level of biological productivity of a waterbody. Florida LAKEWATCH and many professionals classify levels of biological productivity using four trophic state categories — **oligotrophic**, **mesotrophic**, **eutrophic**, and **hyper-eutrophic**. Of the four trophic state categories, the mesotrophic state is defined as having a moderate level of biological productivity. (The prefix “meso” means mid-range.)

A mesotrophic waterbody is capable of producing and supporting moderate populations of living organisms (plants, fish, and wildlife). Mesotrophic waterbodies generally have:

- ◆ moderate nutrient concentrations;
- ◆ moderate growth of algae, aquatic macrophytes or both;
- ◆ water clear enough (visibility of 8 to 13 feet) that most swimmers are not repelled by its appearance and can generally see potential underwater hazards.

☞ See *Trophic state*.

Morphometry (Morphometric)

is the measurement of shapes. Morphometric parameters of a waterbody can be best understood by looking at a detailed map of the waterbody, preferably a map showing the contours of the bottom (called a **bathymetric** map). Morphometric parameters of a waterbody also include its mean depth, maximum depth, shoreline length, volume, and size of its basin. These characteristics significantly affect all aspects of how a waterbody functions.

☛ *See Mean depth.*

Nitrogen

is an element that, in its different forms, stimulates the growth of aquatic macrophytes and algae in waterbodies. Nitrogen is represented in the Periodic Table of Elements as N.

☛ *See Limiting nutrient, Nutrients, and Total nitrogen.*

Nutrients

are chemicals that algae and aquatic macrophytes need for growth. Nitrogen and phosphorus are the two most influential nutrients in Florida waterbodies. Nutrients in waterbodies can come from a variety of sources.

In most cases nutrients are carried into a waterbody primarily when water drains through the surrounding rocks and soils, picking up nitrogen and phosphorus compounds along the way. For this reason, knowledge of the geology and physiography of an area can provide insight into how much nutrient enrichment can be reasonably expected in an individual waterbody from this natural source.

For example, lakes in the New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) can be expected to have low



Joe Richard

Florida LAKEWATCH volunteers collect monthly samples for nutrient analysis.

nutrient levels because they are in a nutrient-poor geographic region. Whereas, lakes in the Lakeland/Bone Valley Upland lake region in central Florida (in Polk and Hillsborough Counties) can be expected to have very high nutrient levels because the land surrounding the lakes is nutrient-rich.

There are many other sources of nutrients, however, and they are generally not as substantial as nutrient contributions from surrounding rocks and soils. Some occur naturally, and others are the result of human activity. For example nutrients are conveyed in rainfall, stormwater runoff, seepage from septic systems, bird and animal feces, and the air itself. Most nutrients can move easily through the environment. They may come from nearby woods, farms, yards, and streets — anywhere in the watershed.

☛ *See Algae, Aquatic macrophytes, Chlorophyll, Lake regions, Limiting nutrients, Total nitrogen and Total phosphorus.*

Oligotrophic

is an adjective used to describe the level of biological productivity of a waterbody. Florida LAKEWATCH and many professionals classify levels of biological productivity using four trophic state categories — **oligotrophic**, **mesotrophic**, **eutrophic**, and **hypereutrophic**.

Of the four trophic state categories, the oligotrophic state is defined as having the lowest level of biological productivity. (The prefix “oligo” means scant or lacking.)

An oligotrophic waterbody is capable of producing and supporting relatively small populations of living organisms (plants, fish, and wildlife). The low level of productivity in oligotrophic waterbodies may be the result of low levels of limiting nutrients in the water, particularly nitrogen or phosphorus, or by other limiting environmental factors.

Oligotrophic waterbodies generally have the following characteristics:

- ◆ Nutrients are typically in short supply, and aquatic macrophytes and algae are less abundant.
- ◆ Oligotrophic waterbodies typically have less plant

debris accumulated on the bottom over the years since aquatic macrophytes and algae are less abundant.

- ◆ Oligotrophic waterbodies often tend to have water clarity greater than 13 feet, due to low amounts of free-floating algae in the water column. The clarity may be decreased however, by the presence of color (from dissolved substances), stirred-up bottom sediments, or stormwater runoff (particulate matter).
- ◆ Fish and wildlife populations will generally be small, because food and habitat are often limited. Oligotrophic waterbodies usually do not support abundant populations of sportfish such as largemouth bass and bream, and it usually takes longer for individual fish to grow in size. Fishing may be good initially if the number of anglers is small, but can deteriorate rapidly when fishing pressure increases and fish are removed from the waterbody.
- ◆ A waterbody may have oligotrophic characteristics even though it has high nutrient levels. This can occur when a factor other than nutrients is limiting the growth of aquatic macrophytes and algae. For example, a significant amount of suspended sediments (stirred-up sediments or particles washed in from the watershed) or darkly colored water can retard macrophyte and algae growth by blocking sunlight.

☛ *See Color, Limiting environmental factors, Limiting nutrient, Nutrients, Secchi depth, Total nitrogen, Total phosphorus, Trophic state, and Water clarity.*

Looks can be deceiving...

Because oligotrophic waterbodies typically have such clear water (Secchi depth readings greater than 13 feet), people often mistakenly think these waters are pure and healthy for human consumption. Unfortunately, human disease and death can be caused by bacteria, pathogens, and other toxic substances that are invisible to the naked eye. It should not be assumed that any surface water is safe to drink — no matter how clear it looks. It should also be noted that in Florida, fish having some of the highest levels of mercury have been caught in oligotrophic waters.

PAC

is an abbreviation for **percent area covered** and is a measure of the percentage of the bottom area of a waterbody with aquatic macrophytes growing on, or over it. Aquatic scientists use PAC to assess the abundance and importance of aquatic plants in a waterbody.



Joe Richard

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had PAC values ranging from 0 to 100%. PAC values are linked with the biological productivity (trophic state) of waterbodies:

- ◆ In the least productive (oligotrophic) waterbodies, PAC values are usually low. In rare cases where they are high (occasionally reaching 100%), it is usually because a thin layer of small plants is growing along the bottom.
- ◆ In moderately productive (mesotrophic) and highly productive (eutrophic) waterbodies, PAC values are generally greater than those measured in oligotrophic waterbodies, and the average plant biomass is also greater.
- ◆ In extremely productive (hypereutrophic) waterbodies dominated by planktonic algae, PAC values are often less than 25%. In Florida however, many hypereutrophic waterbodies contain mostly aquatic macrophytes, not algae. In these cases, PAC values often tend to be greater than 75%.

☛ *See Algae, Aquatic macrophyte, Average plant biomass, and Trophic state.*

Particulates

are any substances in small particle form that are found in waterbodies, often suspended in the water column. Substances in water are either in particulate form or dissolved form. Passing water through a filter will separate these two forms. A filter will trap most of the particulates, allowing dissolved substances to pass through.

Periphyton

are algae attached to underwater objects such as aquatic plants, docks, and rocks. There are several types of periphyton. They're named according to where they grow as follows:

- ◆ **epiphytic** algae grow on the surface of aquatic plants;
- ◆ **epipelic** algae are attached to sediments;
- ◆ **epilithic** algae are attached to rocks; and
- ◆ **benthic** algae grow along the bottom of a waterbody (including epipelic and epilithic algae).

Periphyton communities contribute to a lake's overall biological productivity. Not only do they provide food and habitat for fish and invertebrates, but they can also affect nutrient movement through the aquatic ecosystem in important ways. For example, when periphyton are abundant, they can absorb nutrients from the water so effectively that the growth of free-floating forms of algae may be restricted.

Periphyton are not typically measured by Florida LAKEWATCH. Water samples taken by LAKEWATCH volunteers are used to measure only free-floating algae, called **phytoplankton**, suspended in the water column.

☞ *See **Algae, Biological productivity, Nutrients, Phytoplankton, and Water clarity.***

pH

is a scale of numbers from 0 through 14 that is used to indicate the acidity of a waterbody. Water is said to be **acidic** if the pH is below 7, and **basic** when the pH is above 7. A pH value of 7 is considered **neutral**, which means it's neither acidic or basic. The scientific definition of pH is "the negative logarithm of the hydrogen ion (H⁺) concentration."

It's important to note that each one of the 14 increments on the pH scale represents a ten-fold change in acidity. For example, lake water with a pH of 5.0 is ten times more acidic than lake water with a pH of 6.0. Scales used in this manner are "logarithmic" like the Richter scale used for determining earthquake intensity.

The Role of pH in Waterbodies:

pH influences aquatic biological systems in a variety of ways. In the early years of the 20th century, pH was regarded as the "master variable" and was routinely studied by aquatic scientists in an attempt to understand its complex role. Studies have established that the pH values in waterbodies range from less than 4 to over 10. Waterbodies in the low end of the pH scale are of particular interest to scientists concerned about the effects of acid rain on aquatic plants, fish, and wildlife.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had pH values ranging from less than 4 to nearly 12. Approximately half of the Florida lakes sampled have pH values between 5.8 and 7.8.

☞ *See **Water quality (for Florida standards).***

The location of a waterbody has a strong influence on its pH. For example, lakes in the Okefenokee Plains lake region in north Florida (in Baker, Columbia, and Hamilton Counties) tend to have pH values below 4.8, and lakes in the Lakeland/Bone Valley Upland lake region in central Florida (in Polk and Hillsborough Counties) tend to have values above 7.5.

☞ *See **Lake region.***

Fish, plants and wildlife have different sensitivities to pH. For example, the young of some fish species cannot survive in water that has a pH below 5.0. However, with few exceptions, lakes with low pH in Florida are able to support healthy fish populations.

Most living organisms in Florida systems appear to be well adapted to acidic conditions, possibly because low pH seems to be a naturally-occurring environmental factor. Consequently, many aquatic scientists do not consider acid rain to be as great a threat to Florida's waterbodies as it is to those in the northeastern United States.

Health Concerns:

pH is not generally thought of as a known human health concern. However, when pH is lower than 5.0, some people experience eye irritation.

pH is important in municipal drinking water supplies. The acceptable range of pH for drinking water is generally from 6.5 to 8.5. This range, however, is not based on direct health concerns, but is primarily based on minimizing the corrosion and encrustation of metal water pipes. However, pH can affect drinking water supplies as described below.

- ◆ When pH is lower than 6.5 or exceeds 8.5, chlorine in drinking water supplies becomes a less effective disinfectant.
- ◆ When pH is lower than 6.5 or exceeds 8.5, chlorine in drinking water supplies can contribute to the formation of cancer-causing trihalomethanes.
- ◆ When pH of drinking water is in the acidic range, it can cause copper pipes and lead soldering in pipes to dissolve.

Phosphorus

is an element that, in its different forms, stimulates the growth of aquatic macrophytes and algae in waterbodies. Phosphorus is represented in the Periodic Table of Elements as **P**.

☞ See *Limiting nutrient, Nutrients, and Total phosphorus.*

Physiographic region

is a geographic area whose boundaries enclose territory that has similar physical geology (i.e., soil types, land formations, etc.).

Phytoplankton

are microscopic, free-floating aquatic plant-like organisms suspended in the water column. They are sometimes called **planktonic algae** or just **algae**.

Though individual phytoplankton are tiny in size, they can have a major influence on a waterbody. For example, phytoplankton abundance often determines how biologically productive a waterbody can be; small amounts of phytoplankton often



Christine Taylor

result in less fish and wildlife. Also, the public is concerned about the abundance of phytoplankton, because it significantly affects water clarity.

Aquatic scientists assess phytoplankton abundance by estimating its biomass. This is known as “relative abundance.” Two common methods used are: (1) viewing phytoplankton through a microscope and counting each organism, and (2) measuring chlorophyll concentrations in water samples. Florida LAKEWATCH uses the chlorophyll method because it’s faster and less costly.

☞ See *Algae and Chlorophyll.*

Planktonic algae

☞ See *Phytoplankton.*

Plant biomass

☞ See *Average plant biomass.*

Plant frequency (%)

☞ See *Frequency of occurrence.*

Plant species

☞ See *Common plant name and Scientific plant name.*

Potassium

is an important mineral and a nutrient necessary for plant growth. It’s found in many soils and constitutes a little over 2% of the earth’s crust. Natural sources of potassium are numerous in aquatic environments. Man-made sources include industrial effluents and run-off from agricultural areas. (Potassium is used extensively in crop fertilizers.) Its chemical symbol from the Periodic Table of Elements is **K**.

The Role of Potassium in Waterbodies:

Because potassium salts are readily soluble in water, potassium is found primarily in dissolved form in waterbodies rather than in particulate form.

The concentration of potassium in natural surface water is generally less than 10 mg/L, but

potassium concentrations as high as 100 mg/L can occur. Potassium is essential to plant and animal nutrition. Because potassium concentrations in freshwaters are generally adequate for meeting the nutritional needs of the biological community, potassium is not usually considered as being a limiting nutrient like phosphorus and nitrogen.

☛ See *Limiting nutrient and Particulates*.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had potassium levels ranging from 0 to 50 mg/L. Over 75% of these waterbodies had potassium concentrations less than 3.2 mg/L. Higher potassium concentrations generally occur naturally along the coast, because marine waters have higher average potassium concentrations than freshwater. If potassium concentrations in a coastal area waterbody are uncharacteristically high, it may indicate saltwater is seeping through the ground into the waterbody, called **saltwater intrusion**.

Health Concerns:

Potassium concentrations at the levels found in freshwaters cause no known direct or indirect human health problems.

PVI

is a measure of the percentage of a waterbody's volume that contains aquatic macrophytes. Historically, PVI was an abbreviation for the phrase **percent volume infested** with aquatic plants. Recently it has become an abbreviation for the more neutral phrase **percent volume inhabited**. Regardless of the terminology, PVI is used to assess the abundance and importance of aquatic macrophytes in a waterbody.



Amy Richard

☛ See *Algae, Aquatic macrophyte, Average plant biomass, and Trophic state*.



Joe Richard

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had PVI values ranging from 0 to 100%. In Florida, PVI values are strongly linked with the biological productivity (trophic state) of waterbodies as described below:

- ◆ In the least biologically productive (oligotrophic) waterbodies, PVI values are generally very low.
- ◆ In moderately biologically productive (mesotrophic) waterbodies and highly productive (eutrophic) waterbodies dominated by aquatic plants, PVI values are higher than those measured in oligotrophic waterbodies.
- ◆ Highly biologically productive (hypereutrophic) waterbodies dominated by algae usually have very low PVI values. Hypereutrophic waterbodies dominated by aquatic plants, usually have very high PVI values.

Salinity

is the saltiness of water and is influenced by leaching rock and soil formations, runoff from a watershed, atmospheric precipitation and deposition, and evaporation. It is measured in units of parts per thousand (abbreviated “ppt”). The Atlantic Ocean and the Gulf of Mexico typically have salinity values around 35 ppt, although there is significant variation, particularly in near shore areas. Salinity often tends to be lower in areas receiving inflows of freshwater, like the mouths of rivers. Salinity often tends to be higher in areas where the evaporation rate is high — in hot, dry climates.

☛ See *Chloride, Sodium, and Specific conductance*.

Scientific plant name

is a name used by scientists to help avoid the confusion caused by the use of common plant names, which often tend to be inconsistent. Professionals have assigned a unique scientific name to each plant. Scientific names are usually based on Latin or Greek words and are written in italics or underlined. For example, the aquatic plant whose common name is maidencane has the scientific name *Panicum hemitomon*.

A scientific plant name consists of two parts. The first part is called the “family name” or **genus** and the second part refers to the **species**. For example, *Potamogeton pectinatus* is the scientific name of a specific species of pondweed. *Potamogeton* is the genus and *pectinatus* is the species. *Potamogeton illinoensis* is a different species of pondweed. By using scientific names, containing both genus and species, scientists can be very specific.

➔ See *Common plant name and Plant species*.

Secchi depth

is a measurement that indicates water clarity. Traditionally, the transparency or water clarity of a waterbody is measured using an 8-inch diameter disc called a **Secchi disc** – named for its inventor, Pietro Angelo Secchi. A Secchi disc is usually painted in alternating quadrants of black and white, though it can also be solid white. A cord is attached through the center of the disc and is marked off in intervals, usually in feet or meters.

To measure water clarity, the disc is lowered into the water to find the depth at which it first vanishes from the observer’s sight. (Note: if the disc can still be seen as it rests on the lake bottom or if it disappears into plant growth, the depth at which this happens is not considered the Secchi depth.)

➔ See *Water clarity*.



LAKEWATCH uses solid white Secchi discs, as shown here.

Joe Richard

Silica

is the name for compounds containing silicon in combination with oxygen. **Silicon** is the second most abundant element in the earth’s crust, and **silica** is found in all waterbodies. Silica generally occurs in freshwaters in both dissolved and particulate forms. Silicon is represented in the Periodic Table of Elements as **Si** and the chemical formula for soluble silica is **H₄SiO₄**.

Although human activities (i.e., fluoridation of drinking water and some industrial processes), are sources of silica, even pristine waters contain silica compounds. Many freshwaters contain less than 5 mg/L of silica, while concentrations as high as 4000 mg/L have been measured in saline waterbodies.

The Role of Silica in Waterbodies:

Silica is considered an essential micronutrient for microorganisms and diatoms (a type of algae). These organisms use silica to form shells and other protective structures. Diatoms are capable of using large amounts of silica, and diatom populations may be limited when silica is in short supply. Silica concentrations in water are affected by several mechanisms. For example:

- ◆ As diatom populations increase, the rate at which they pull silica from the water also increases (usually in the Spring). This can result in a decline of silica concentrations in the water.
- ◆ Silica is removed from the water column altogether when diatoms die and sink to the bottom, forming silica-enriched sediments.
- ◆ When pH is above 7, the amount of dissolved silica in the water column is affected by the presence of iron and aluminum; either one can reduce the amount of dissolved silica in the water column.
- ◆ The amount of silica in the water column can increase when humic compounds (organic substances that make water tea-colored) are present.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had silica levels ranging from 0 to about 14 mg/L. Over 75% of these waterbodies had silica concentrations less than 2.4 mg/L.

Health Concerns

Silica poses no known threat to human health at the concentrations found in waterbodies.

Sodium

is the sixth most abundant element on earth. Sodium is often associated with chloride; common table salt is mostly sodium chloride. Sodium is used extensively in industrial processes, food processing, and in some water softening devices. Sodium is represented in the Periodic Table of Elements as **Na**.

The Role of Sodium in Waterbodies:

All waters contain sodium. Sodium is essential to all animals and some microorganisms and plants. Generally, sodium is not considered a limiting factor for freshwater organisms, unless sodium concentrations reach levels at which freshwater organisms cannot survive. As sodium concentrations increase in a waterbody, there can be a continuous transition from freshwater organisms to those adapted to brackish water and then ultimately, to marine (saltwater) organisms. High sodium concentrations can be expected in the following:

- ◆ areas near the coast that receive sodium-enriched groundwater from saltwater intrusion;
- ◆ areas where evaporation is excessive (perhaps in hot and/or dry climates); and
- ◆ areas receiving human pollution including agricultural runoff containing fertilizer residues, discharges containing human or animal waste, and backwash from water softeners using the sodium exchange process.

☛ *See Chloride, Salinity, Surface water, and Limiting nutrient.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had sodium concentrations which ranged from 1 to over 1100 mg/L. Over 75% of these waterbodies had sodium concentrations less than 13 mg/L. The higher concentrations of sodium are found in lakes located near the coast and in lakes where the groundwater entering the lakes has been in contact with natural salt deposits.

Health Concerns:

At the concentrations found in freshwaters, sodium generally causes no known direct threat to human health.

Specific conductance

is a measure of the capacity of water to conduct an electric current. A higher value of conductance means that the water is a better electrical conductor. The unit of measure for conductance can be expressed in two ways:

- ◆ **microSieman per centimeter of water measured at a temperature of 25 degrees Celsius** (abbreviated $\mu\text{S}/\text{cm}$ @ 25° C).
- ◆ **Micromhos per centimeter** (abbreviated **micromhos/cm** or $\mu\text{mhos}/\text{cm}$).

The Role of Specific Conductance in Waterbodies:

Specific conductance increases when more of any salt including the most common one, sodium chloride, is dissolved in water. For this reason, conductance is often used as an indirect measure of the salt concentration in waterbodies. In general, waters with more salts are the more productive ones — except, of course, where there are limiting nutrients or limiting environmental factors involved.

Natural factors can also cause higher conductance values in the open water. For example, drought conditions can increase the salt concentrations in a waterbody in two ways: (1) drought can cause inflowing waters to have higher salt concentrations, and (2) heat and low humidity can increase the rate of evaporation in open water, leaving the waterbody with a higher concentration of salt.

Because animal and human wastes (sewage, feed lot effluent, etc.) contain salts, the measurement of conductance can be used for the detection of contamination. Since most discharges of industrial and municipal wastewater directly into lakes in Florida have been stopped, measurements of conductance are now used in this context primarily to detect septic tank seepage along shorelines. It's important to keep in mind that elevated conductance measurements may have various causes and do not by themselves prove there is contamination from human or animal wastes.

☛ *See Biological productivity, Chloride, Limiting environmental factors, Limiting nutrient, Salinity, and Sodium.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had average conductance values that ranged from 11 to over 5500 $\mu\text{S}/\text{cm}$ @ 25° C. Over 75% of these waterbodies had conductance values less than 190 $\mu\text{S}/\text{cm}$ @ 25° C.

The location of a waterbody has a strong influence on its conductance. For example, lakes in the New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) tend to have conductance values below 20 $\mu\text{S}/\text{cm}$ @ 25° C. While lakes in the Winter Haven/Lake Henry Ridges lake region in central Florida (in Polk County) tend to have values above 190 $\mu\text{S}/\text{cm}$ @ 25° C.

☛ *See Water quality (for Florida standards).*

Health Concerns:

There are no known human health concerns directly related to specific conductance. In waters where human or animal waste contamination is suspected, bacterial tests should be conducted regardless of whether conductivity values are high.

☛ *See Lake region.*

Submersed plants

are large plants that grow primarily below the water’s surface. Eelgrass, hydrilla, and coontail are examples of submersed plants. Some of these plants are rooted to the waterbody’s bottom sediments, like eelgrass and hydrilla; while some, like coontail, are not.

☛ *See Aquatic macrophytes.*



Joe Richard

Submersed vegetation provides habitat for fish. Many aquatic scientists consider this its most important role.

The Role of Submersed Aquatic Plants in Waterbodies:

The importance of having submersed vegetation and the amount of submersed vegetation necessary to achieve specific management goals are both subjects of ongoing research and debate at the present time. In general, submersed aquatic plants perform several functions in waterbodies. Some of them are described below.

- ◆ Submersed vegetation provides habitat for fish. Many aquatic scientists consider this its most important role.
- ◆ Submersed vegetation provides food and habitat for wildlife populations (fish, ducks, invertebrates).
- ◆ Submersed vegetation affects nutrient cycles and other chemical cycles in complex ways.
- ◆ Submersed vegetation can increase water clarity.
- ◆ Submersed vegetation stabilizes bottom sediments.
- ◆ Submersed vegetation can increase or decrease dissolved oxygen concentrations, depending on its abundance and the availability of light.
- ◆ Submersed vegetation contributes to the filling-in of waterbodies by depositing decayed material that accumulates on the bottom.

☛ *See Aquatic macrophytes and Submersed plant biomass.*

In Florida:

Submersed plants occur in virtually all Florida waterbodies. In an individual waterbody, the availability of light, water clarity, water depth, and sediment stability affect where submersed plants will grow.

Professional management of aquatic plants in Florida is extensive, because native and non-native submersed plants can reach nuisance levels. An abundance of submersed aquatic plants can adversely affect recreational boating, swimming, fishing, and fish populations. Also, some people find submersed aquatic plants to be aesthetically unappealing.

Health Concerns:

Submersed plants are not generally considered a danger to human health, but they can cause problems indirectly in some circumstances. For example:

- ◆ submersed plants can camouflage underwater objects, obstructing the ability of swimmers and boaters to see potential hazards;
- ◆ submersed plants can entangle swimmers.

Submersed plant biomass

(as used by Florida LAKEWATCH) is the average weight of fresh, live submersed aquatic macrophytes growing in one square meter area of a waterbody. The measurement of the average submersed plant biomass is one of several measurements that can be used to assess a waterbody's overall biological productivity and to assess the potential importance of submersed plants.

☞ See *Average plant biomass and Biological productivity*.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had an average fresh weight of submersed plants ranging from 0 to over 22 kg wet wt/m². The biological productivity of a waterbody is strongly related to submersed plant biomass. This relationship is summarized as follows:

- ◆ In biologically unproductive (oligotrophic) waterbodies, the average submersed plant biomass is about 0.5 kg wet wt/m².
- ◆ In moderately productive (mesotrophic) waterbodies, the average submersed plant biomass is about 1.0 kg wet wt/m².
- ◆ In highly productive (eutrophic) waterbodies, the average submersed plant biomass is about 2.0 kg wet wt/m².
- ◆ In the most highly productive (hypereutrophic) waterbodies, where algae are not the dominant plants, the average submersed plant biomass is about 5.0 kg wet wt/m².

☞ See *Trophic state and each of its categories: Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic*.

Sulfates

are chemical compounds that contain the elements sulfur and oxygen. They are widely distributed in nature and can be dissolved into waterbodies in significant amounts. The chemical formula for sulfates is SO_4^- .

There are a variety of diverse sources for sulfates in waterbodies. Sulfate concentrations in a waterbody are influenced primarily by natural deposits of minerals and organic matter in its watershed. Sulfate is also widely used in industry and agriculture, and many wastewaters contain high concentrations of sulfate. Acidic rainfall (containing sulfuric acid) is a major source of sulfate in some waterbodies.

The primary source of sulfate in rain in industrialized areas is through atmospheric discharges from power plants that burn sulfur-containing fuels and from certain industries.

The primary source of sulfate in rain in non-industrialized areas is through atmospherically oxidized hydrogen sulfide (the chemical symbol for hydrogen sulfide is H_2S) which is produced along coastal regions by anaerobic bacteria. Volcanic emissions also contribute sulfur to the atmosphere.

The Role of Sulfur in Waterbodies:

Sulfate is used by all aquatic organisms for building proteins. Sulfur changes from one form to another (known as “cycling”) in quite complex ways. Sulfur cycling can influence the cycles of other nutrients like iron and phosphorus and can also affect the biological productivity and the distribution of organisms in a waterbody.

Bacteria can significantly influence the sulfur cycle in water. For example, under conditions where dissolved oxygen is lacking, certain bacteria can convert sulfate to hydrogen sulfide gas (H₂S). Hydrogen sulfide gas has a distinctive rotten egg smell, and in high concentrations can be toxic to aquatic animals and fish.

☞ See *Biological productivity and Nutrients*.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had sulfate concentrations which ranged from 0 to about 500 mg/L. Over 75% of these waterbodies had concentrations of sulfates less than 20 mg/L.

Health Concerns:

Sulfates pose no known direct threat to human health. In some Florida lakes, the decomposition of large deposits of organic matter along the shorelines will cause the formation of pockets of hydrogen sulfide gas in the bottom sediments. On the rare occasion when people step into these pockets, they can experience a burning sensation on their skin. Florida natives may refer to these sediments as “hot mud.”

Surface water

is water found on the earth’s surface. It is distinguished from **groundwater** which is found underground.

Surface waters include many types of waterbodies such as lakes, rivers, streams, estuaries, ponds and reservoirs.



UF/IFAS Center for Aquatic and Invasive Plants

Total alkalinity

is a measure of water’s capacity to neutralize acids. Total alkalinity is often abbreviated **TALK**. The unit of measure for total alkalinity is generally **milligrams per liter of total alkalinity as equivalent calcium carbonate** (abbreviated **mg/L as CaCO₃**). Even though alkalinity is expressed in units that reference calcium carbonate, alkalinity levels are not determined by calcium carbonate alone.

The alkalinity of a waterbody is influenced by the soils and bedrock minerals found in its watershed and by the amount of contact the water has had with them. For example, lakes in limestone regions, which are rich in calcium carbonate, often tend to have higher values for alkalinity. Those in sandy soil regions, which are poor in calcium carbonate, often tend to have lower values.

Alkalinity (and its opposite, acidity) can also be influenced significantly by the presence of several different substances, for example:

- ◆ phosphorus (in phosphatic soils and rocks);
- ◆ nitrogen (from ammonia);
- ◆ silica (from silicates);
- ◆ organic acids (like humic acids); and
- ◆ gases (specifically carbon dioxide and hydrogen sulfide).

☞ See *pH*.

When alkalinity is a concern, it’s generally related to the formation of a crusty accumulation of calcium deposits, called **scale**, in tanks and pipes.

☞ See *Calcium*.

The Role of Alkalinity in Waterbodies:

Total alkalinity is a major determinant of the acid neutralizing capacity (ANC) of waterbodies. High alkalinity waters are often more biologically productive than low alkalinity waters. Consequently, total alkalinity was once used as an indirect measure of a lake’s productivity. In recent years, research has shown that waterbodies with low alkalinity levels are more susceptible to the effects of acidic water inputs such as acid rain.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had total alkalinity concentrations ranging from 0 to over 300 mg/L as CaCO₃. Over 75% of these waterbodies had total alkalinity concentrations less than 35 mg/L as CaCO₃.

☛ See *Water quality (for Florida standards)*.

The location of a waterbody has an especially strong influence on its total alkalinity concentration. For example, lakes in the Okefenokee Plains lake region in north Florida (in Baker, Columbia, and Hamilton Counties) tend to have total alkalinity values of 0 mg/L as CaCO₃. While lakes in the Tsala Apopka lake region in central Florida (in Citrus, Sumter, and Marion Counties) tend to have values above 40 mg/L as CaCO₃.

☛ See *Lake region*.

Health Concerns:

There is no known level of total alkalinity in Florida waterbodies that indicates a threat to human health.

Total chlorophyll

is a measure of all types of chlorophyll. The abbreviation for total chlorophyll is **TCHL**.

☛ See *Chlorophyll*.

Total nitrogen

is a measure of all the various forms of nitrogen that are found in a water sample. Nitrogen is a necessary nutrient for the growth of aquatic plants and algae. Not all forms of nitrogen can be readily used by aquatic plants and algae, especially nitrogen that is bound with dissolved or particulate organic matter. The chemical symbol for the element nitrogen is “N,” and the symbol for total nitrogen is “TN.”

Total nitrogen consists of inorganic and organic forms. Inorganic forms include nitrate (NO₃⁻), nitrite (NO₂⁻), unionized ammonia (NH₄),

A Better Way...

Chlorophyll measurements are useful in assessing the trophic state of a body of water. However, the use of chlorophyll measurements alone may produce misleading results; chlorophyll measurements don't take into account the biological productivity expressed in the form of aquatic macrophytes. Assessments that also include aquatic plant abundance would be more accurate, particularly in waterbodies with significant macrophyte populations.



LAKEWATCH volunteers filter lake water to obtain chlorophyll samples.

☛ See *Aquatic macrophytes and Chlorophyll*.

ionized ammonia (NH₃⁺), and nitrogen gas (N₂). Amino acids and proteins are naturally-occurring organic forms of nitrogen. All forms of nitrogen are harmless to aquatic organisms except unionized ammonia and nitrite, which can be toxic to fish. Nitrite is usually not a problem in waterbodies, however, because (if there is enough oxygen available in the water for it to be oxidized) nitrite will be readily converted to nitrate.

☛ See *Nitrogen*.

The Role of Nitrogen in Waterbodies:

Like phosphorus, nitrogen is an essential nutrient for all plants, including aquatic plants and algae. In some cases, the 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 or **TN/TP < 10**). TN in water comes from both natural and man-made sources, including:

- ◆ air (some algae can “fix” nitrogen — pulling it out of the air in its gaseous form and converting it to a form they can use);
- ◆ stormwater run-off, including natural run-off from areas where there is no human impact (nitrogen is a naturally-occurring nutrient found in soils and organic matter);
- ◆ fertilizers; and
- ◆ animal and human wastes (sewage, dairies, feedlots, etc.).

☛ *See Algae, Algal biomass, Chlorophyll, Limiting nutrient, and Phytoplankton.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had total nitrogen concentrations which ranged from less than 50 to over 6000 µg/L. Using these average concentrations of total nitrogen from this same database, Florida lakes were found to be distributed into four trophic states as follows.⁶

- ◆ approximately 14% of these lakes (those with TN values less than 400 µg/L) would be classified as *oligotrophic*;
- ◆ about 25% of these lakes (those with TN values between 401 and 600 µg/L) would be classified as *mesotrophic*;
- ◆ 50% of these lakes (those with TN values between 601 and 1500 µg/L) would be classified as *eutrophic*; and
- ◆ nearly 11% of these lakes (those with TN values greater than 1500 µg/L) would be classified as *hypereutrophic*.

☛ *See Trophic state and each of its categories: Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic; and Water quality.*

⁶ This distribution of trophic state is based solely on total nitrogen values without utilizing information on total phosphorus, chlorophyll, water clarity, or aquatic macrophyte abundance.

The location of a waterbody has a strong influence on its total nitrogen concentration. For example, lakes in the New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) tend to have total nitrogen values below 220 µg/L. While lakes in the Lakeland/Bone Valley Upland lake region in central Florida (in Polk and Hillsborough Counties) tend to have values above 1700 µg/L.

☛ *See Lake region.*

Health Concerns:

The concentration of total nitrogen in a waterbody is not a known direct threat to human health. It is the individual forms of nitrogen that contribute to the total nitrogen measurement and the use of the water that need to be considered. For example, nitrate in drinking water is a concern. Drinking water with nitrate concentrations above 45 mg/L has been implicated in causing blue-baby syndrome in infants. The maximum allowable level of nitrate, a component of the total nitrogen measurement, is 10 mg/L in drinking water. Concentrations of nitrate greater than 10 mg/L generally do not occur in waterbodies, because nitrate is readily taken up by plants and used as a nutrient.

Total phosphorus

is a measure of all the various forms of phosphorus that are found in a water sample. Phosphorus is an element that, in its different forms, stimulates the growth of aquatic plants and algae in waterbodies. The chemical symbol for the element phosphorus is **P** and the symbol for total phosphorus is **TP**. Some phosphorus compounds are necessary nutrients for the growth of aquatic plants and algae. Phosphorus compounds are found naturally in many types of rocks. Mines in Florida and throughout the world provide phosphorus for numerous agricultural and industrial uses.

The Role of Phosphorus in Waterbodies:

Like nitrogen, phosphorus is an essential nutrient for the growth of all plants, including aquatic plants and algae. Phosphorus in waterbodies takes several forms, and the way it changes from

one form to another (called **cycling**) is complex. Because phosphorus changes form so rapidly, many aquatic scientists generally assess its availability by measuring the concentration of total phosphorus rather than the concentration of any single form. In some waterbodies, phosphorus may be at low levels that limit further growth of aquatic plants and/or algae. In this case, scientists say phosphorus is the **limiting nutrient**.

For example, in waterbodies having TP concentrations less than 10 µg/L, waters will be nutrient poor and will not support large quantities of algae and aquatic plants.

There are many ways in which phosphorus compounds enter waterbodies. The more common ones are described below:

- ◆ Some areas of Florida and other parts of the world have extensive phosphate deposits. 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 to increase fish production by fertilizing aquatic macrophyte 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.

☞ See *Algae, Limiting nutrient, Phytoplankton, Total nitrogen, Water clarity, and Water quality.*

In Florida:

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. Using these average concentrations of total phosphorus from this same database, Florida lakes were found to be distributed into the four trophic states as follows:⁷

- ◆ approximately 42% of these lakes (those with TP values less than 15 µg/L) would be classified as *oligotrophic*;
- ◆ about 20% of these lakes (those with TP values between 15 and 25 µg/L) would be classified as *mesotrophic*;

Judging a lake by its label...

Although it's unreasonable to do so, the trophic state classification of a waterbody is sometimes used as an indicator of "good" or "bad" quality. For example, because oligotrophic waterbodies often have very clear water, they are commonly characterized as being "good." While typical eutrophic and hypereutrophic waterbodies, with their pea soup green water and naturally weedy shorelines, might be seen as being "bad."

Neither of these characterizations is necessarily fair; the judgement of the quality of a waterbody should depend on how it is going to be used. For instance, fish caught in supposedly "good" oligotrophic waterbodies of Florida have some of the highest concentrations of mercury in the state, making them potentially "bad" sites for catching a fish dinner. Similarly, so-called "bad" eutrophic and hypereutrophic waterbodies support some of Florida's most abundant fish and bird populations, making them, in reality, potentially "good" sites for fishing and birdwatching.

So, it's not sufficient to judge the quality of a waterbody by its trophic state alone. Instead, one should consider what specific qualities are desirable or undesirable based on how you intend to use the waterbody.

☞ See *Trophic state.*

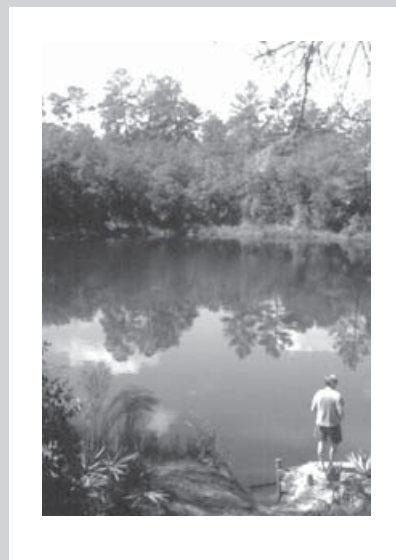


Photo courtesy of UF/IFAS Center for Aquatic and Invasive Plants.

◆ 30% of these lakes (those with TP values between 25 and 100 $\mu\text{g/L}$) would be classified as *eutrophic*; and

◆ nearly 8% of these lakes (those with TP values greater than 100 $\mu\text{g/L}$) would be classified as *hypereutrophic*.

☞ See *Trophic state* and each of its categories: *Oligotrophic*, *Mesotrophic*, *Eutrophic*, and *Hypereutrophic*; and *Water Quality*.

The location of a waterbody has a strong influence on its total phosphorus concentration. For example, lakes in the New Hope Ridge/Greenhead Slope lake region in northwestern Florida (in Washington, Bay, Calhoun, and Jackson Counties) tend to have total phosphorus values below 5 $\mu\text{g/L}$. While lakes in the Lakeland/Bone Valley Upland lake region in central Florida (in Polk and Hillsborough Counties) tend to have values above 120 $\mu\text{g/L}$.

☞ See *Lake region*.

Health Concerns:

There is no known level of total phosphorus in waterbodies that poses a direct threat to human health.

Transparency

☞ See *Water clarity*.

Trophic state

is defined as “the degree of biological productivity of a waterbody.” Scientists debate exactly what is meant by **biological productivity**, but it generally relates to the amount of algae, aquatic macrophytes, fish and wildlife a waterbody can produce and sustain.

Waterbodies are traditionally classified into four groups according to their level of biological productivity. The adjectives denoting each of these trophic states, from the lowest productivity level to the highest, are **oligotrophic**, **mesotrophic**, **eutrophic**, and **hypereutrophic**.

⁷ This distribution of trophic state is based solely on total phosphorus values without utilizing information on total nitrogen, chlorophyll, water clarity, or aquatic macrophyte abundance.



Joe Richard

A bum rap...

Since waterbodies with low concentrations of TP (total phosphorus) 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.

Aquatic scientists assess trophic state by using measurements of one or more of the following:

- ◆ total phosphorus concentrations in the water;
- ◆ total nitrogen concentrations in the water;
- ◆ total chlorophyll concentrations — a measure of free-floating algae in the water column; and
- ◆ water clarity, measured using a Secchi disc; and
- ◆ aquatic plant abundance.

Florida LAKEWATCH professionals base trophic state classifications primarily on the amount of chlorophyll in water samples. Chlorophyll concentrations have been selected by LAKEWATCH as the most direct indicators of biological productivity, since the amount of algae actually being produced in a waterbody is reflected in the amount of chlorophyll present. In addition, Florida LAKEWATCH professionals may modify their chlorophyll-based classifications by taking the aquatic macrophyte abundance into account.

☞ See *Algae*, *Biological productivity*, *Chlorophyll*, *Eutrophic*, *Hypereutrophic*, *Mesotrophic*, *Nutrients*, *Oligotrophic*, and *Trophic State Index (TSI)*.

Trophic State Index (TSI)

is a scale of numbers from 1 to 100 that can be used to indicate the relative trophic state of a waterbody. Low TSI values indicate lower levels of biological productivity, and higher TSI values indicate higher levels. The use of TSI is an attempt to make evaluations of biological productivity easier to understand.

Using mathematical formulas, TSI values can be calculated individually for four parameters: total nitrogen concentrations, total phosphorus concentrations, total chlorophyll concentrations, and Secchi depth. Sometimes a single TSI value for a waterbody is calculated by combining selected individual TSI values.

The State of Florida classifies waterbodies according to “designated uses” that have been assigned to each. (See **Water Quality** in this circular for a more detailed description.)

The Florida Department of Environmental Protection (FDEP) assesses water quality in Florida by evaluating whether each waterbody is able “to support its designated use.”⁸ The FDEP assessment is based solely on TSI values as follows:

- ◆ waterbodies with TSI values from 0 to 59 are rated as “good and fully support use;”
- ◆ those waterbodies with TSI values between 60 to 69 are rated as “fair and partially support use;” and
- ◆ waterbodies with TSI values from 70 to 100 are rated as “poor and do not support use.”

Individual TSI values may be further combined in a special type of averaging to produce an **Average Trophic State Index** (abbreviated **TSI_{ave}**).⁹ Government and regulatory agencies responsible for water management often use the average value, overlooking the fact that the designing author, Dr. Robert Carlson of Kent State University in Ohio, never intended TSI values to be reduced to a single number. TSI values for individual parameters could differ markedly within any specific waterbody, and this significant variation will be obscured when the **TSI_{ave}** is calculated.

Dr. Carlson has noted that TSI values should not be averaged; consideration of the differences in individual TSI values in a waterbody can provide insight and a better understanding of its biological productivity.



Marilyn Bachmann

Pitfalls of using TSI...

Applying words like *good*, *fair*, and *poor* to TSI ranges has contributed to the unfortunate misconception that trophic state is synonymous with the concept of water quality. While higher TSI values indicate waterbodies with high levels of biological productivity, this is not necessarily a “poor” condition.

This can lead to evaluations that are confusing. For example, consider a waterbody with a TSI of 80. Its high TSI rating tells us that the lake has a high level of biological productivity — a capacity to support abundant populations of fish and wildlife.

However, if we use Environmental Protection standards (see left column adjacent to this text), the same TSI rating of 80 puts the waterbody in the category described as “poor and does not support use,” regardless of the fact that it is, in reality, able to support an abundance of fish and wildlife. While this lake may not be ideal for swimming or diving, it is fully able to support recreational activities such as fishing and bird watching.

➔ See ***Trophic state and Water Quality***.

⁸ *The Florida Water Quality Assessment 305 (b) Report, 1996.*

⁹ *In Florida, the Secchi depth parameter is often not incorporated into the TSI calculations because so many of Florida’s lakes are darkly colored waters. Also, the Florida Department of Environmental Protection uses only the measurements of total nitrogen and total phosphorus when the concentration of total chlorophyll is not available. If either of the nutrient concentrations is not available, however, FDEP will not calculate the TSI.*

The Florida LAKEWATCH Program does not use the TSI system (neither the TSI_{ave} nor individual TSI values). Instead LAKEWATCH finds it more informative to use the individual values of the four measured parameters without transforming them into TSI values.

☛ *See Trophic State, Water Clarity, and Water Quality.*

Water clarity

is the transparency or clearness of water. While many people tend to equate water clarity with water quality, it's a misconception to do so. Contrary to popular perceptions, crystal clear water may contain pathogens or bacteria that would make it harmful to drink or to swim in, while pea-soup green water may be harmless.

Water clarity in a waterbody is commonly measured by using an 8-inch diameter Secchi disc, attached to a string/rope. The disc is lowered into the water, and the depth at which it vanishes from sight is measured. Measured in this way, water clarity is primarily affected by three components in the water:

- ◆ free-floating algae called **phytoplankton**,
- ◆ dissolved organic compounds that color the water reddish or brown; and
- ◆ sediments suspended in the water, either stirred up from the bottom or washed in from the shore.

Water clarity is important to individuals who want the water in their swimming areas to

☛ *See Algae, Humic acids, and Secchi depth.*



Joe Richard

be clear enough so that they can see where they are going. In Canada, the government recommends that water should be sufficiently clear so that a Secchi disc is visible at a minimum depth of 1.2 meters (about 4 feet).

This recommendation is one reason that many eutrophic and hypereutrophic lakes that have abundant growths of free-floating algae do not meet Canadian standards for swimming and are deemed undesirable. It should be noted that these lakes are not necessarily undesirable for fishing nor are they necessarily polluted in the sense of being contaminated by toxic substances.

☛ *See Trophic State.*

The Role of Water Clarity in Waterbodies:

Water clarity will have a direct influence on the amount of biological production in a waterbody. When water is not clear, sunlight cannot penetrate far and the growth of aquatic plants will be limited. Consequently aquatic scientists often use Secchi depth (along with total phosphorus, total nitrogen, and total chlorophyll concentrations) to determine a waterbody's trophic state.

Water clarity affects plant growth, but conversely, the abundance of aquatic plants can affect water clarity. Generally, increasing the abundance of submersed aquatic plants to cover 50% or more of a waterbody's bottom may have the effect of increasing the water clarity.

One explanation is that either submersed macrophytes (plants), or perhaps algae attached to aquatic macrophytes, use the available nutrients in the water, depriving the free-floating algae of them. Another explanation is that the submersed macrophytes anchor the nutrient-rich bottom sediments in place — buffering the action of wind, waves, and human effects — depriving the free-floating algae of nutrients contained in the bottom sediments that would otherwise be stirred up.

Because plants must have sunlight in order to grow, water clarity is also directly related to how deep underwater aquatic macrophytes will be able to live. This depth can be estimated using Secchi depth readings.

☞ See *Aquatic macrophytes, Algae, Biological productivity, Chlorophyll, Color, Particulates, Phytoplankton, Secchi depth, Trophic state, and Water quality.*

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998 had Secchi depths ranging from less than 0.2 to over 11.6 meters (from about 0.7 to 38 feet).

☞ See *Water quality.*

The trophic state of a waterbody can be strongly related to the water clarity. Using these average Secchi depth readings from the Florida LAKEWATCH database analyzed prior to January 1998, Florida lakes were found to be distributed into the four trophic states as follows:¹⁰

- ◆ approximately 7% of the lakes would be classified as *oligotrophic* (those with Secchi depths greater than 3.9 meters or about 13 feet);
- ◆ about 22% of the lakes would be classified as *mesotrophic* (those with Secchi depths between 2.4 and 3.9 meters — or between about 8 to 13 feet);
- ◆ 45% of the lakes would be classified as *eutrophic* (those with Secchi depths between 0.9 and 2.4 meters — or between about 3 to 8 feet); and
- ◆ 26% of the lakes would be classified as *hyper-eutrophic* (those with Secchi depths less than 0.9 meters or about 3 feet).

☞ See *Trophic state and each of its categories: Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic.*

The location of a waterbody has a strong influence on its water clarity. For example, lakes in the New Hope Ridge/Greenhead Slope lake region (Washington, Bay, Calhoun, and Jackson Counties) tend to have Secchi depths greater than 9 feet (3 meters). While lakes in the Lakeland/Bone Valley Upland lake region (in Polk and Hillsborough Counties) tend to have Secchi depths less than 3 feet (0.9 meters).

☞ See *Lake region.*

Health Concerns:

Water clarity is not known to be directly related to human health.

Water depth

is the measurement of the depth of a waterbody from the surface to the bottom sediments. Water depth can vary substantially within a waterbody based on its morphology (shape). Florida LAKEWATCH volunteers measure water depth using a weighted Secchi disk attached to a string or cord that is marked in one-foot increments. The weighted Secchi disk is dropped down until it hits bottom and then the distance is determined by measuring the length of rope between the bottom and the surface of the water. These measurements are then recorded for future reference.

Water depth can also be measured using a device called a fathometer — by bouncing sonic pulses off the bottom and electronically calculating the depth. Fathometer readings taken continuously along a number of transects (shore-to-shore trips across the waterbody) are used to calculate an average lake depth. The calculated average lake depth is approximately the same as the waterbody's average water depth, called **mean depth**.

☞ See *Mean Depth, PVI (Percent Volume Infested or Inhabited), PAC (Percent Area Covered), and Submersed aquatic plants.*

Water quality

is a subjective, judgmental term used to describe the condition of a waterbody in relation to human needs or values. The phrases “good water quality” or “poor water quality” are often related to whether the waterbody is meeting expectations about how it can be used and what the attitudes of the waterbody users are.

Water quality is not an absolute. One person may judge a waterbody as being high quality, while

¹⁰ This distribution of trophic state is based solely on Secchi depth values without utilizing information on nutrient concentrations, chlorophyll concentrations or aquatic macrophyte abundance.

Joe Richard



someone with a different set of values may judge the same waterbody as being poor quality. For example, a lake with an abundance of aquatic macrophytes in the water may not be inviting for swimmers but may look like a good fishing spot to anglers.

Water quality guidelines for freshwaters have been developed by various regulatory and governmental agencies. For example, the Canadian Council of Resource and Environmental Ministers (CCREM) provides basic scientific information about the effects of water quality parameters in several categories, including raw water for drinking water supply, recreational water quality and aesthetics, support of freshwater aquatic life, agricultural uses, and industrial water supply.

☛ See **Recommended Reading** at the end of this circular.

Water quality guidelines developed by the Florida Department of Environmental Protection (FDEP) provide standards for the amounts of some substances that can be discharged into Florida waterbodies (Florida Administrative Code 62.302.530). The FDEP guidelines provide different standards for waterbodies in each of five classes that are defined by their assigned designated use as follows:

- Class I waters are for **POTABLE WATER SUPPLIES**;
- Class II waters are for **SHELLFISH PROPAGATION OR HARVESTING**;
- Class III waters are for **RECREATION, PROPAGATION AND MAINTENANCE OF A HEALTHY, WELL-BALANCED POPULATION OF FISH AND WILDLIFE**;
- Class IV waters are for **AGRICULTURAL WATER SUPPLIES**; and
- Class V waters are for **NAVIGATION, UTILITY AND INDUSTRIAL USE**.

☛ See **Biological productivity, Trophic state, Trophic State Index (TSI), and Water clarity**.

All Florida waterbodies are designated as Class III unless they have been specifically classified otherwise (refer to Chapter 62-302.400, Florida Administrative Code for a list of waterbodies that are not Class III). Excerpts from the FDEP guidelines, including some of the parameters measured by Florida LAKEWATCH, are shown in the table on page 37.

Watershed

is the area from which water flows into a waterbody. Drawing a line that connects the highest points around a waterbody is one way to delineate a watershed's boundary. A more accurate delineation would also include areas that are drained into a waterbody through underground pathways. In Florida, these might include drainage pipes or other man-made systems, seepage from high water tables, and flow from springs. Activities in a watershed, regardless of whether they are natural or man-made, can affect the characteristics of a waterbody.

Width of emergent and floating-leaved zone (Average)

is an estimate of the average width (in meters or feet) of the lake zone that is colonized by emergent and floating-leaved plants. It's estimated from the shoreline to the lakeward edge of the plants.

☛ See **Emergent plants and Floating-leaved aquatic plants**.

In Florida:

Waterbodies in the Florida LAKEWATCH database analyzed prior to January 1998, had emergent and floating-leaved zone widths that ranged from 0 meters to completely covering a waterbody's surface. When waterbodies have significant coverage by emergent and floating-leaved plants, it would probably be more accurate to call them deep water marshes, instead of lakes.

FDEP Standards for Class III Freshwaters, partial list (Florida Administrative Code 62.302.530)

Parameter	Standard	Unit of Measure
Alkalinity	Shall not be depressed below 20.	mg/L as CaCO ₃
Chlorides	No standard.	
Conductance, specific	Shall not be increased more than 50% above background or to 1275, whichever is greater.	micromhos/cm
Nitrate	No standard.	µg/L
(a) nutrients	The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Sections 62.302.300, 62-302,700 and 62.242, F.A.C.	µg/L
(b) nutrients	In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.	µg/L
pH	Shall not vary more than one unit above or below natural background or more than two-tenths unit above or below natural background of open waters, provided that the pH is not lowered to less than 6 units or raised above 8.5 units. If natural background is less than 6 units, the pH shall not vary below natural background or vary more than one unit above natural background or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background or more than two-tenths unit below natural background of open waters.	
Transparency	Shall not be reduced by more than 10% as compared to the natural background values.	Depth of the compensation point for photosynthetic activity.

Recommended Reading

Florida LAKEWATCH publications

are available by request. Call: 1-800-LAKEWATCH (1-800-525-3928).

◆ Florida LAKEWATCH Newsletters

containing educational articles on various topics are available on the Florida LAKEWATCH web site at <http://www.ifas.ufl.edu/~LAKEWATCH/index.htm> or by contacting the LAKEWATCH office and requesting a copy.

◆ Florida LAKEWATCH Data: What Does It All Mean?

◆ Florida Lake Regions: A Classification System

◆ Trophic State: A Waterbody's Ability to Support Plants, Fish, and Wildlife

◆ Information Circular 101: A Beginner's Guide to Water Management—The ABCs

◆ Information Circular 102: A Beginner's Guide to Water Management—Nutrients

◆ Information Circular 103: A Beginner's Guide to Water Management—Water Clarity

Note: The circulars listed above are only the first three of a series; check with the LAKEWATCH office or website for an updated listing.

Florida-specific Research and Information

Bachmann, M., M.V. Hoyer, and D.E. Canfield, Jr. 1999. Living at the Lake: A Handbook for Florida Lakefront Property Owners. University of Florida, Institute of Food and Agricultural Sciences. Publication SP 247.

Canfield, D.E. Jr., K.A. Langeland, M.J. Maceina, W.T. Haller, J.V. Shireman, and J.R. Jones. 1983. Trophic state classification of lakes with aquatic macrophytes. Canadian Journal of Fisheries and Aquatic Sciences. 40: 1713-1718.

Hoyer, M.V. and D.E. Canfield, Jr. 1994. Handbook of Common Freshwater Fish in Florida Lakes. University of Florida, Institute of Food and Agricultural Sciences. Publication SP 160.

Hoyer, M.V., D.E. Canfield, Jr., C.A. Horsburgh, K. Brown. 1996. Florida Freshwater Plants. A Handbook of Common Aquatic Plants in Florida Lakes. University of Florida, Institute of Food and Agricultural Sciences. Publication SP 189.

Other Relevant Research and Information

- Boyd, C.E. 1990. *Water Quality in Ponds and Aquaculture*. Auburn University, Auburn, Alabama.
- Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.
- Carlson, R.E. 1979. A review of the philosophy and construction of trophic state indices. p. 1-52. [In] T.E. Maloney (ed.). *Lake and Reservoir Classification Systems*. U.S. Environmental Protection Agency. EPA 600/3-79-074.
- Carlson, R.E. 1980. More complications in the chlorophyll-Secchi disk relationship. *Limnology and oceanography*. 25:378-382.
- Carlson, R.E. 1981. Using trophic state indices to examine the dynamics of eutrophication. p. 218-221. [In] *Proceedings of the international Symposium on Inland Waters and Lake Restoration*. U.S. Environmental Protection Agency. EPA 440/5-81-010.
- Carlson, R.E. 1983. Discussion on "Using differences among Carlson's trophic state index values in regional water quality assessment," by Richard A. Osgood. *Water Resources Bulletin*. 19:307-309.
- Carlson, R.E. 1984. The trophic state concept: a lake management perspective. p.427-430. [In] *Lake and Reservoir Management: Proceedings of the Third Annual conference of the North American Lake Management Society*. U.S. Environmental Protection Agency. EPA 440/5-84-001.
- Carlson, R.E. 1992. Expanding the trophic state concept to identify non-nutrient limited lakes and reservoirs. pp. 59-71 [In] *Proceedings of a National Conference on Enhancing the States' Lake Management Programs. Monitoring and Lake Impact Assessment*. Chicago.
- CCREM (Canadian Council of Resource and Environment Ministers). 1995. *Canadian Water Quality Guidelines*. Prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers.
- Chamberlin, T.C. 1890 (original printing); 1965 (reprinted). The Method of Multiple Working Hypotheses. *Science*. 24: 754-758
- Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. *Restoration and Management of Lakes and Reservoirs*. Second edition. Lewis Publishers.
- Forsberg, C. and S.O. Ryding, 1980. Eutrophication parameters and trophic state indices in 30 Swedish waste-receiving lakes. *Archiv fur Hydrobiologie* 88: 189-207.
- Ryding, S.O. and W. Rast. 1989. The control of eutrophication of lakes and reservoirs. *Man and the Biosphere series*, UNESCO, Paris. 314p.
- Wetzel, R.G. 1983. *Limnology*. Second Edition. Saunders College Publishing.

