Florida
LAKEWATCH

Dedicated to Sharing Information About Water Management and the Florida LAKEWATCH Program Volume 60 (2013)

LAKEWATCH Continues to be a Large Part of Florida Fish and Wildlife Conservation Commission's (FWC) Long-Term Fish Monitoring Program

David Watson

Regional Coordinator Dan Willis and LAKEWATCH Chemist Claude Brown prepare to sample for the long-term fish monitoring program on Lake Ivanhoe in downtown Orlando.

The primary law of the land impacting aquatic resources is the United States Federal Water Pollution Control Act or " Clean Water Act" (CWA, United States Code title 33, sections 1251-1387). The commonly defined intent of this act is to "restore and maintain the chemical, physical and biological integrity of the Nations waters." Chemical and physical aspects are relatively straight forward, but the CWA does not define biological integrity nor does it recommend scientific methods to measure condition of the aquatic biota. The CWA also leaves it to individual states to define biological integrity and set water quality goals to protect aquatic life in their water bodies. Focusing more on fish and wildlife (biological integrity), we examined the mission statements of 37 state agencies in charge of fish and wildlife that had set mission statements and they all incorporate at least two major components 1) protecting fish and wildlife for the benefit of people and 2) Protecting fish and wildlife for the future. The Florida Fish and Wildlife Conservation Commission (FWC) has one of the most direct and succinct mission statements: "To manage fish

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and wildlife resources for their long-term well-being and the benefit of people."

These are still broad sweeping statements and individual states need to more clearly define specific goals that are measurable and later manageable. Only by inventorying and monitoring can state agencies hope to attain these goals by assessing current status and trends in fish populations. The challenge is to carry out a sampling protocol to provide generalized insights among and within water bodies, yet be logistically feasible with the limited time and funding most state agencies possess and this is where LAKEWATCH stepped in to assist the long-term fish monitoring program in Florida lakes.

In 1999, Florida LAKEWATCH with the help of FWC initiated an un-contracted fish-monitoring program. The funds for this program were assembled from multiple residual resources. The fish communities in 30 lakes were sampled with electrofishing in the springs of 1999 through 2006. In the fall of 2007 dedicated funding became available and Florida LAKEWATCH shifted community sampling from spring to fall to coincide with the FWC's fish community sampling. This shift would allow for better pooling and comparison of data into the future. At the start of the fish monitoring program, the general goals were to: 1) to examine the long-term variation in fish communities from a range of lakes in relation to: lake trophic status, aquatic macrophyte abundance, and lake morphology, 2) educate citizens in the functioning of Florida fish populations and 3) facilitate the interaction and cooperation among Florida citizens, the Program for Fisheries and Aquatic Sciences, the University of Florida/Institute of Food and Agricultural Sciences, and FWC.

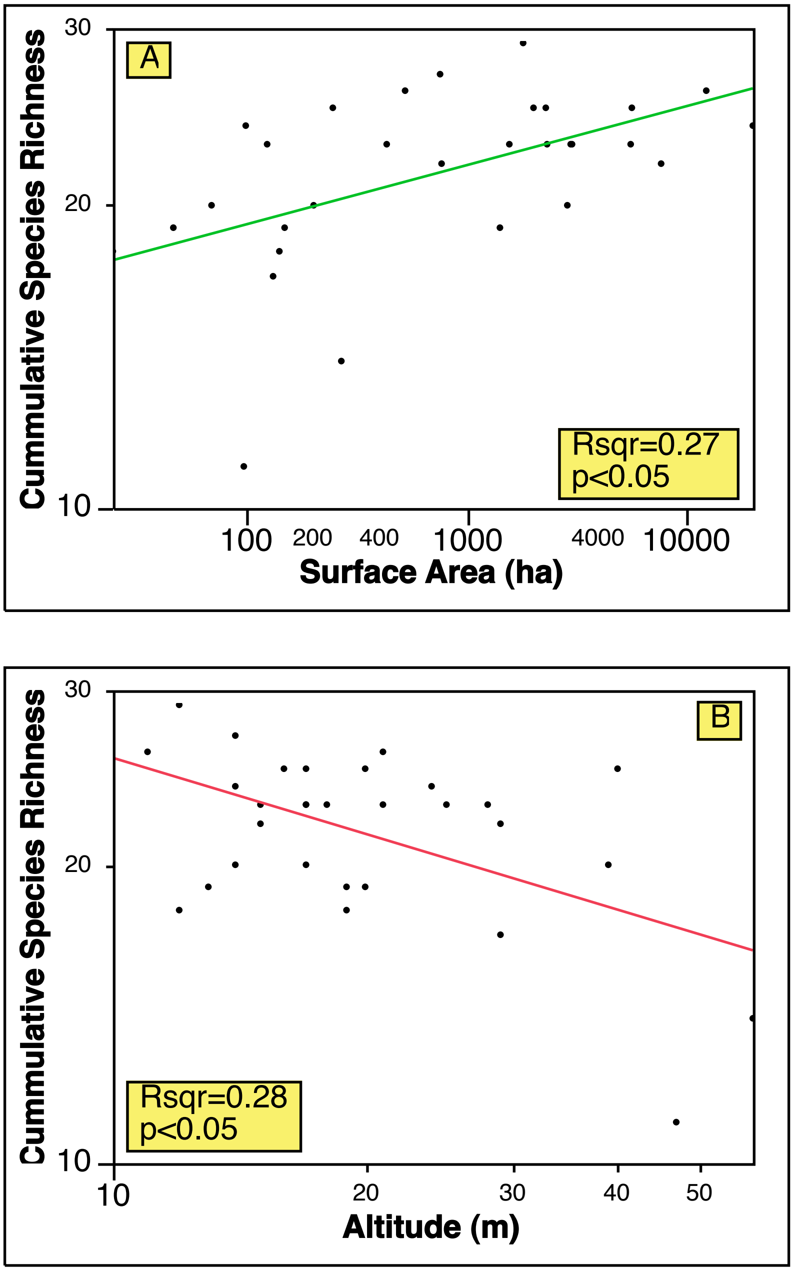
The fish monitoring continues into 2013 but LAKEWATCH staff just recently published a paper[1] describing the findings from the first eight years of sampling. In this paper the data collected during these eight years of fish monitoring were used to examine the variance associated with this type of monitoring and the relations between lake characteristics and fish community measures. The paper also reports on the wisdom acquired during this effort and how this wisdom can help better define goals and mechanisms of a fish-monitoring program both for the fish community and the benefit of people.

The following are some of the early findings from the long-term fish-monitoring program:

1) Only six 10-minute electrofishing transects were used annually per lake to estimate the catch per unit effort (CPUE fish/hour) total fish, sport fish, and each individual fish species. Examining the variability in these transects showed that to better estimate the CPUE in a lake biologists would need to sample

Dan Willis

Regional Coordinator David Watson measures a largemouth bass during a sampling event for the long-term fish monitoring program.



Relationships between cumulative electrofishing fish species richness and both lake surface area (A) and altitude (B) for 30 Florida lakes.

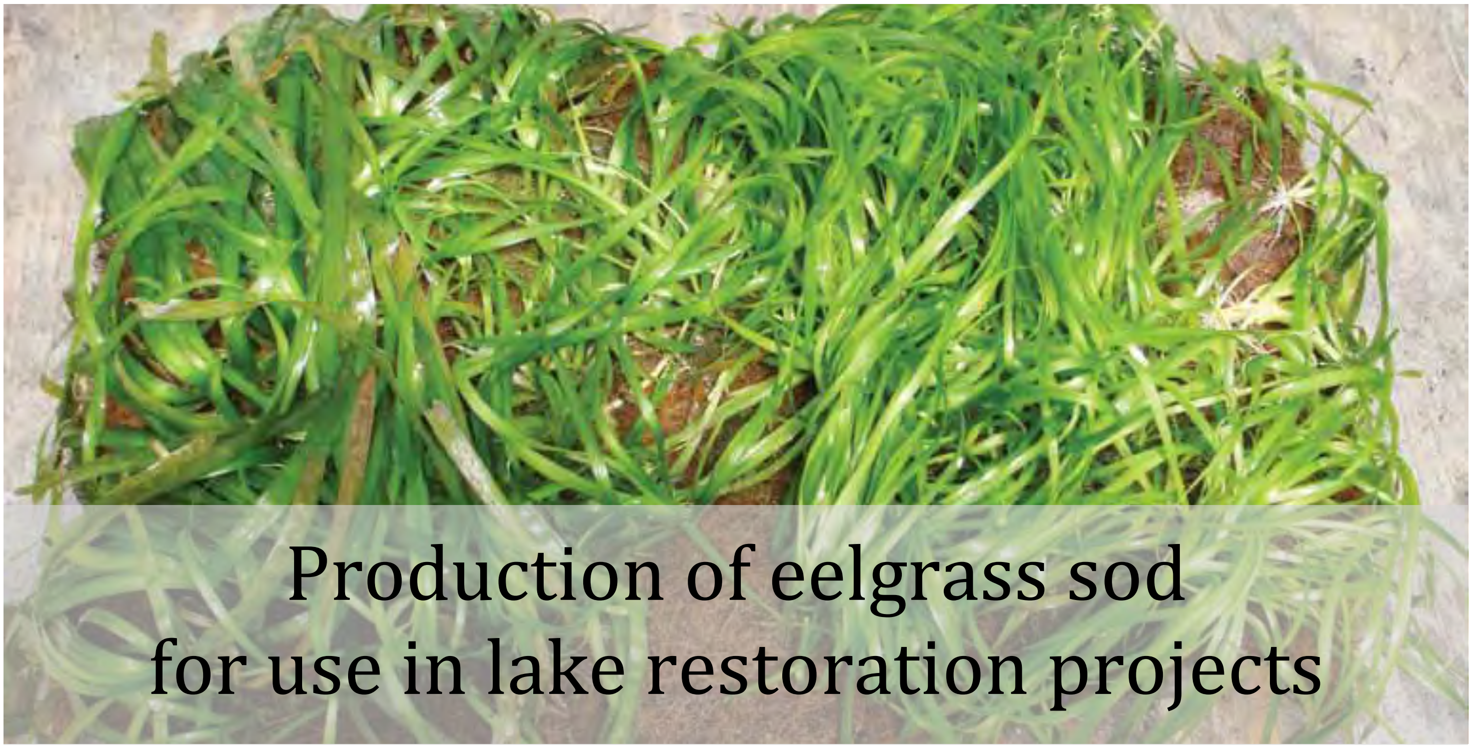
double or triple the number of transects, which is currently being done for the monitoring program.

2) Florida LAKEWATCH volunteers annually estimated lake trophic status on all of these lakes by measuring chlorophyll concentrations, which showed a direct positive relation with total and sport fish even with low sampling effort, giving a general ability to estimate CPUE in Florida lakes after measuring lake trophic status.

3) Eight years of repeated sampling yielded a robust estimate of how many fish species existed in each lake. This species richness number corresponds well with both lake surface area and the altitude in which the lake resides. Larger lakes have more fish species than smaller lakes probably because of more varying habitat types that occur in larger lakes. Lakes at a higher altitude generally have less species than lakes closer to the main drainage system, which probably serves as a fish species reserve. This information should help lake managers interested in monitoring fish species and where there may be problems with survival of rare species.

Many federal, state, and local agency leaders and professionals struggle with spending money to monitor environmental factors, flora and/or fauna of aquatic system because they believe it is spending money on information and not actually on managing problems in these systems. However, these same individuals are often aggravated because there is no 20-year historical record on an aquatic system to help make management decisions and achieve desired management goals. Thus, monitoring is a necessity that has to be accomplished as cost effectively as possible yet rigorous enough to provide information needed for management. So thank you Florida LAKEWATCH volunteers for your tireless efforts making programs like long-term fish monitoring possible, our hats are off to you again.

[[1]- Hoyer, M. V., J. P. Bennett and D. E. Canfield, Jr. 2011. Monitoring freshwater fish in Florida lakes using electrofishing: Lessons learned. Lake and Reservoir Management. 27:1-14.]



Production of eelgrass sod for use in lake restoration projects

By Lyn A Gettys, William T. Haller, Ed Hayes and Kyle Thayer

The Aquatic Habitat Restoration and Enhancement Subsection of the Florida Fish and Wildlife Conservation Commission (FWC) is charged with planning and executing lake restoration projects in Florida. Fish and wildlife populations are healthiest when submersed aquatic vegetation (SAV) is present, so SAV is often planted to improve habitat quality for fish and wildlife. Lake restoration projects rely on the use of native SAV to maintain ecological integrity. Eelgrass (*Vallisneria americana*) is a highly desired candidate for inclusion in these programs for a variety of reasons. Eelgrass (also called tapegrass or American watercelery) is a perennial submersed aquatic herb with ribbon-like leaves arising from a central rosette. The species is widely adapted and is more tolerant of adverse environmental conditions such as high turbidity, low light levels and various water chemistry regimes, than other native SAV. Although eelgrass produces seeds, most colonization is the result of vegetative reproduction of ramets (plantlets).

Revegetation efforts at some sites have been effective and newly planted eelgrass thrives, but in other cases, establishment of self-sustaining populations of SAV has been unsuccessful. This could be due in part to the techniques used to plant SAV in the field. The roots of field-collected plants used for revegetation are sometimes damaged during collection, which can cause transplant shock and failure to establish. Also, the typical procedure is to hand-plant individual ramets, a technique that is very tedious and labor-intensive. This is especially true when ramets are planted at a fairly high density as recommended for best establishment. In response to this dilemma, the FWC requested that researchers at the University of Florida Center for Aquatic and Invasive Plants partner with their lake restoration biologists to investigate techniques and develop methods to optimize field plantings and hopefully improve restoration success.

Eelgrass sod in the greenhouse

In these experiments, we assessed the feasibility of producing eelgrass “sod” that can be cultured in the greenhouse and transplanted to the field. This novel approach addresses several of the challenges associated with revegetation programs. First, a relatively small number of plants are needed to start sod in the greenhouse; this can be desirable if supplies of eelgrass are limited. Second, sod can be cultured under greenhouse conditions, which drastically reduces predation and grazing while plants become established. Third, instead of planting individual ramets in the field, high-density populations are transplanted, which improves the likelihood of field establishment.

Finally, large swaths of the restoration site can be planted quickly, which can reduce labor costs.

Our first goal was to identify the best matrix in which to culture eelgrass sod. This matrix had to be biodegradable to facilitate its breakdown after planting, but also stable and solid enough to support the sod during greenhouse culture and hold up during transport to the field. We tested two potential matrix materials – 100% cotton burlap and 1” thick coir (coconut fiber) – to determine which material would best serve our purposes. We cut sheets of each matrix to 1.5’ x 2’ and inserted eight rooted plantlets on 6” centers through the matrix. Planted sheets were placed on a layer of sand amended with a controlled-release fertilizer in 1.5’-deep tanks filled with well water. As newly planted sheets had a tendency to float, each sheet was weighted down with 2 bricks that were placed between the newly planted ramets. After 16 weeks of culture, we found that most sheets hosted well-established populations of eelgrass, with an average of 80 plants per sheet (a 10-fold increase from the original planting density of 8 ramets per sheet). Matrix type did not have a significant effect on total number of plants produced during the culture period, but mats with a burlap matrix were extremely unstable and fell apart upon removal from culture tanks. In contrast, mats with a coir matrix maintained their structural integrity and held together upon removal from tanks. Because the burlap matrix failed to produce mats that would remain intact during transport from a greenhouse production facility to the transplant site in the field, we selected coir as the best matrix to use for production of eelgrass sod. Based on the results of these experiments, we determined that production of eelgrass sod in the greenhouse was indeed possible and that a coir matrix was superior to a burlap matrix.

Can Eelgrass Sod Work in the Field?

Our next goal was to “ground-truth” this new eelgrass sod technology to determine whether this strategy could be transferred to the field to increase the success rate of restoration projects at areas where previous revegetation efforts have failed. We established additional pieces of sod in the greenhouse, using coir as a matrix and following the procedures described above, then transported the sod to planting sites at three lakes. Well-rooted eelgrass sod was transplanted in the field at single locations in Lakes George, Jesup and Josephine. Water depth at the planting sites was 1.5’ at Lakes George and Jesup and 2’ at Lake Josephine. Planting sites were protected by exclosures at all three locations to reduce the likelihood of herbivory by turtles and other aquatic fauna. Replicate plots were established at each site; some plots were amended with controlled-release fertilizer tablets, whereas other plots were left unfertilized. Eelgrass sod was transplanted at all sites with and without fertilizer, with 4 replicates each of fertilized and unfertilized treatments. Sod was placed on the bottom of the lake and secured with 8” long metal spikes; fertilizer tablets were pushed into the lake sediment under the sod in plots calling for fertilizer. Within 48 hours of planting, sod planted at Lakes George and Jesup had been torn or pulled up by wave action; this problem was addressed by returning to the field and top-dressing sod at these locations with pea gravel to provide more stability. This did not occur at Lake Josephine, where deeper water at the planting site resulted in reduced wave action; it therefore seems likely that planting site instability is a function of water depth.

Ramets of eelgrass inserted in the openings of the coir rope net. Photo by Lyn Gettys.

Field visits 4 months after planting revealed that eelgrass sod had become established with varying degrees of success at the three sites and that there was no difference between fertilized and unfertilized plots. Small plants were visible at the Lake George site, but plants did not extend beyond the original pieces of sod and failed to colonize the unplanted area within the exclosure. It is worth noting that the planting site at Lake George is referred to as the Desert because virtually no SAV is previous plantings have failed to establish. The observation that eelgrass was persistent 4 months after planting suggests that the use of sod may improve the success rate of revegetation efforts at this site. In contrast, plantings of eelgrass sod at Lakes Jesup and Josephine were much more successful. Plants at both sites were well-established and growing vigorously as soon as 2 months after the sod was transplanted. Healthy, self-sustaining populations of eelgrass are still present at both sites more than a year after planting and have expanded to fill the unplanted areas within the exclosures.

Results

These experiments revealed that the use of eelgrass sod for restoration and revegetation projects may be an effective strategy to increase transplant success and improve population establishment. Eelgrass was still present at all three field sites 4 months after planting and populations at these sites have become self-sustaining. Although little growth was evident at the Desert site of Lake George, the fact that eelgrass was still present at the site 4 months after planting is encouraging, as previous revegetation attempts at this site have failed. These results suggest that the use of eelgrass sod may provide a new tool to restoration managers and could result in more successful, cost-effective lake restoration programs. If water at the planting site is shallow (< 1.5'), care should be taken to ensure that sod is securely anchored to the planting site by top-dressing with gravel. Another alternative for shallow-water plantings is to locate the planting site behind existing populations of emergent plants, which will protect the newly planted sod by reducing wave and current action.

Can This Work with Larger Eelgrass Species?

These small-scale studies led us to wonder whether the production of eelgrass sod could be scaled up to produce larger pieces of eelgrass sod. In other words, instead of planting eelgrass sod that covered 3 square feet, why not try to produce sod that would cover 45 square feet? We also wanted to find a way to address the stability issue we found when planting eelgrass sod in shallow water. With these goals in mind, we identified a product that is composed of a large (3' x 15') "pillow" of coir enclosed in a coir rope net. We built large tanks (9' x 45' x 2' deep) out of plywood and pond liners; each tank accommodates 9 of these jumbo-size mats. As with our smaller sod experiments, we found that the coir pillows floated, so they were weighted down with bricks prior to planting. This was one of the few parallels between small-scale and large-scale eelgrass sod production. We set up a total of 4 of these tanks to produce 36 pieces of eelgrass sod, for a total of over 1600 square feet of coverage. The first tank to be planted had 20 g of controlled-release fertilizer per square foot broadcast over the bottom of the tank before the mats were placed directly on top of the pond liner in the tank. This is half the low label rate recommended by the fertilizer manufacturer for culture of terrestrial nursery plants and approximately equal to the rate used in our production of small eelgrass sod. The water level in the tank was brought up to around 1' and well-rooted ramets of eelgrass were inserted on 6" centers into the openings in the coir rope net wrapped around the coir pillow. Once planting was complete, the water level in the tank was increased to 1.5' and maintained at that level throughout the culture period. It quickly became clear that our protocol for production of small eelgrass sod could not be scaled up for production of large eelgrass sod without modifications. The tank became murky within a week and an algae bloom of epic proportions reduced water clarity to virtually zero. Pumps and biofilters were installed in an attempt to control the algae to no avail. We continued to have algae problems so severe that they impeded the eelgrass growth by blocking sunlight and smothering the plants.

Faced with this dilemma, we reduced the fertilizer level to 10 g per square foot in the next three tanks we planted. This helped to reduce – but did not eliminate – algae problems. Finally, the algae problems in the first tank were so severe that we abandoned the tank and set up replacement mats in a new tank. In this iteration, we placed and planted the mats as before, but did not add any fertilizer to the tank before planting. Instead, we waited until the eelgrass started to grow well (around 4 weeks after planting), then inserted a 7.5 g controlled release fertilizer tablet under the planted mats at 1 foot intervals (equivalent to 5 g per square foot). This strategy seemed to work very well; plant density and establishment quickly increased and the algae blooms noted in earlier plantings failed to materialize.

After 4 to 5 months of culture, all mats were well-populated and hosted robust populations of eelgrass. Transport to the field was accomplished by rolling each 3'-wide piece of sod onto a 4' length of aluminum fence post, which acts as a spool and provides handles on either end of the roll. This process was fairly quick (a 15' long piece of sod could be rolled in 5 minutes) and resulted in an easy-to-transport unit that could be taken to the field. Although a rolled 3' x 15' piece of eelgrass sod is fairly heavy when saturated, the coir drains rapidly and weighs around 50 pounds within a few minutes of being removed from the tank. Sod is rolled with the shoots of the eelgrass inside and the drained coir retains enough water to ensure that plants do not desiccate during short transport periods. Rolled eelgrass sod is then loaded onto a boat, transported to the revegetation site, unrolled on the bottom of the site, and secured with 6" long biodegradable stakes.

These large pieces of eelgrass sod were transplanted to field plots in August 2011. While it is too soon to tell whether they will establish robust, self-sustaining populations of eelgrass in the field, it seems likely that they will perform as well or better than the smaller pieces of sod used in our previous trials. We expect that the new material used for the large eelgrass sod will be more stable because the coir pillow is wrapped with a coir rope net, so topdressing the sod with pea gravel at shallow planting sites may not be necessary. We believe these experiments show that the use of eelgrass sod may provide a new tool to restoration managers and could result in more successful, cost-effective lake restoration programs.

Dr. Gettys is an Assistant Professor at the University of Florida's Research and Education Center in Ft. Lauderdale. Sources for materials, supplies and literature used to prepare this paper are available from Dr. Gettys at lgettys@ ufl.edu.

Well-rooted pieces of large (3' x 15') eelgrass sod after 16 weeks of culture. Photo by Lyn Gettys.

Volunteer Bulletin Board

Lab Notes!

As you work hard to collect and process your samples, the folks in the lab want to be sure you get the best and most accurate results possible. Occasionally, we run into a few problems we would like your help to correct in order to get your results back to you as expeditiously as possible. These gentle reminders should be reviewed and shared with those folks helping you sample your lake.

Problem:
Cracked water bottles resulting from bottles being over-filled before freezing.
Solution
When collecting water bottles please fill completely and then pour out some water until you get down to the shoulder of the collection bottle, as this will allow for expansion of the water upon freezing.

Problem:
Chlorophyll filters exposed.
Solution
When folding your algae sample filters, please be sure to fold them exactly in half, with the algae on the inside. (Pretend you're making an "algae taco.") If any part of the algae sample is uncovered and exposed while putting the filter into its wrapper, some of it can rub off the sample filter and stick to the outside wrapper. That portion of the algae is lost and the sample is less than accurate.

Problem
Unlabeled filters or missing information.
Solution
Labeled filters help us keep track of chlorophyll and corresponding water samples as they pass through the lab. A quick double- check to be sure the lake name/county, date, and amount
filtered are recorded is important to get results back to you, our volunteer. In particular the amount filtered is essential to the actual calculations used to determine chlorophyll concentrations.

Problem:
Filters not stored in silica gel dessicant.
Solution:
Filters must be stored in the bottles of silica gel dessicant provided to prevent degradation of your sample due to mold growth.

Problem:
Missing information on data sheets.
Solution:
We ask that you complete the lake/county, date, and write both Secchi depth and water depth measurements on the sheet in the space provided. Visibility and depth information is entered in the long-term database along with your chlorophyll results. Missing information on the data sheet can lead to a delay in information relayed back to you.

You work hard to collect these samples and we all want them to be the very best they can be. Thanks for your help and keep up the good work!

A Gateway to Florida's Lakes

As reported in Vol. 39 of the LAKEWATCH newsletter, Florida LAKEWATCH, the Florida Center for Community Design and Research at the University of South Florida and the Florida Lake Management Society have teamed up to provide easy access to data for all LAKEWATCH lakes. This service is implemented as the "Florida Atlas of Lakes" found at the Water Atlas website (www.wateratlas.org).

This statewide atlas has the key water chemistry data that is generated by the Florida LAKEWATCH program. The Florida Atlas of Lakes manage and deliver data through a map interface. LAKEWATCH sites are matched to map themes based on the 1:24,000 scale National Hydrology Database (NHD). Additional map themes are then added to the base map to create the map that is used as a key element of the database.

The Florida Atlas of Lakes allows the citizens of Florida to better understand and appreciate the important work that is done on their behalf by Florida LAKEWATCH volunteers. Users are able to view data for any of the waterbodies in the Florida LAKEWATCH program.

To visit the Florida Atlas of Lakes go to the website:

http://www.wateratlas.usf.edu/AtlasOfLakes/Florida/

Major Aquifers and Aquifer Systems in Florida

By Rick Copeland P.G. Ph.D
AquiferWatch Inc.

Introduction

In the Volume 58 (Fall 2012) of the **LAKEWATCH** newsletter, it mentioned that **LAKEWATCH** was teaming with **AquiferWatch** to conduct a pilot study to see if the monitoring of groundwater by volunteers in Florida can become a reality. If you live in north-central Florida or in Walton or Okaloosa Counties in the panhandle, please consider participating in the **LAKEWATCH / AquiferWatch** program. If you, or someone you know, is interested, please let your **LAKEWATCH** representative know.

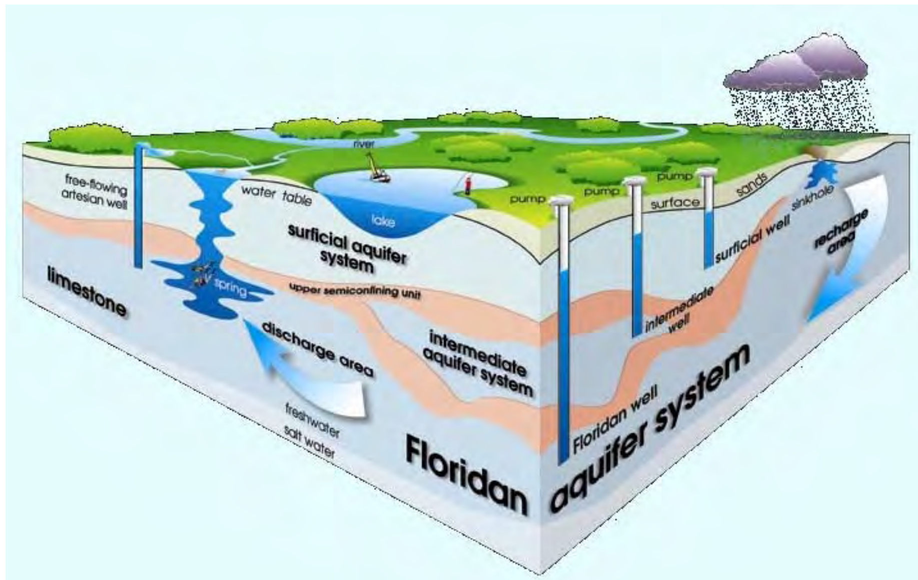


Figure 1. Numerous aquifers underlie Florida. These aquifers are separated from one another by confining units (or beds). (Source: St. Johns River Water Management District).

When it rains, some of the water soaks into our soil and moves downward. It fills cracks, pores, and other openings in the underlying rock and sand. When it encounters the water table, it becomes groundwater. An aquifer is rock formation or stratum that will yield water in sufficient quantity to a well. Permeability is the property of a porous rock to transmit water. Numerous aquifers underlie Florida. These aquifers are separated from one another by confining units (or beds). When compared to aquifers, confining beds are relatively impermeable. This does not mean they are incapable of transmitting groundwater. They simply do not transmit water as well as aquifers do.

Florida is underlain by the Florida Platform. It is made up of thick sequences of carbonate rock, mostly limestones. The limestones were originally deposited at the bottom of the ocean. Over time the platform was intermittently uplifted, relative to the ocean surface. Because of the intermittent nature of the uplift, occasionally sands and clays, originating in Georgia and Alabama intermixed with the deposition of the limestones. However, in many parts of Florida, these sediments simply covered the limestones. Today the uppermost sediments in Florida are generally sands and clays, while limestones and other carbonate rocks are found at depth.

During the uplift, which lasted over millennia, as the limestones rose above the ocean surface, they were exposed to rainfall. Limestones can be dissolved by weak acids, such as rain water and carbonic acid found in Florida's soils. As rain fell and percolated through our soils, the underlying carbonate rocks were slowly dissolved. Pore spaces grew in size. Some eventually became caves. The ability for the rocks to transmit water also grew. Aquifers were created. Occasionally in some of the larger cavities, the roofed collapsed and sinkholes were formed. Today, over much of Florida, the carbonate rocks are at, or are very close to land surface. Where this occurs, the landscape has an abundance of sinkholes and springs are not uncommon.

During the uplift, the rain slowly replaced much of the original saltwater. Today we have fresh water aquifers near the surface, but we have saltier water with depth. In fact, anywhere in Florida, if a well was drilled deep enough, it will eventually encounter salt water.

Beginning in the early 1900s, geologists began mapping and naming aquifers and confining units in Florida. By the early 1980s it was recognized that inconsistencies in mapping methodologies and naming conventions was leading to confusion. For this reason, the Southeastern Geological Society (SEGS) established a committee to attempt to resolve these issues. The committee was made up of representatives from the state of Florida, universities, and the private sector. Although the representatives could not agree on the naming of each of the aquifers in the state, they did reach consensus regarding aquifer systems (Southeastern Geological Society, 1986). The committee decided that an aquifer system consists of one or more aquifers, and for the sake of simplicity, they decided on a three-tiered naming convention for our fresh-water aquifer systems. This act greatly simplified the confusion by "placing" each aquifer into one of the aquifer systems. In the late 2000s, the Florida Geological Survey (FGS) published the hydrogeologic framework in southwest Florida (Arthur et al., 2008). Not only did it describe the detailed hydrogeologic framework in southwest Florida, it also refined the work of the SEGS. The discussion below is a synopsis of the two reports.

Aquifer Systems and Major Aquifers

Because the groundwater becomes saltier with depth, the aquifers systems of interest to most Floridians are the freshwater aquifer systems. In Florida, from shallow to deep, they are the surficial aquifer system (SAS), the intermediate aquifer system or intermediate confining unit (IAS/ICU), and the Floridan aquifer system (FAS). The SAS exists over most of Florida. In portions of Florida the SAS is an important source of water supply. It also supplies water to many of Florida's lakes. The IAS/ICU contains locally important aquifers. Where this occurs, it is often referred to as intermediate aquifer system (IAS). In other portions of the state, producing aquifers are absent and the unit is called the intermediate confining unit (ICU). The FAS is the most important aquifer in Florida and it is the source of drinking water for over 90% of Floridians. Additionally, most of the groundwater discharging from our springs originates from the FAS. The discussion below is restricted to aquifer systems and the most significantly used aquifers in Florida. The names and corresponding abbreviations are listed in Table 1. Beneath the FAS lies a series of salty aquifer systems and confining units. Aquifers within these systems have not been separated (differentiated).

Surficial Aquifer System: The SAS is close to land surface and is comprised mostly of sands and carbonate rocks, other than those of the FAS where the FAS is at, or near, land surface. The SAS generally contains the water table. The two major aquifers within the SAS are the Biscayne aquifer in southeast Florida and the sand-and-gravel aquifer in northwest Florida. The extent of both aquifers, along with the SAS, is displayed in Figure 1. In southeast and northwest, the thickness of the SAS is generally greater than 600 feet. Over most of Florida it is less than 300 feet thick. In north-central and in the eastern panhandle, the SAS does not exist or is only locally present. Figure 1 also indicates that over much of Florida, the SAS is not a significant source of groundwater. This means that less than five percent of a given county's groundwater withdrawals come from the SAS. In these areas, most groundwater is withdrawn from the FAS. In south Florida, and in scattered portions of the rest of the state, the SAS is a significant source of groundwater. Note that in southeast Florida, where it exists, the Biscayne is an important source of groundwater. However, northwest Florida the sand-and-gravel aquifer exists over several counties, but is only a significant source of groundwater in westernmost Florida.

Table 1. Aquifer Systems and Major Aquifers in Florida

Aquifer System	Aquifer	Abbreviation
surficial aquifer system		SAS
	Biscayne aquifer	BA
	sand-and-gravel aquifer	SGA
Intermediate aquifer system or intermediate confining unit Intermediate aquifer system Intermediate confining unit		IAS/ICU IAS ICU
Floridan aquifer system		FAS
	Upper Floridan aquifer	UFA
	Middle Florida Confining Unit	MFCU
	Lower Floridan aquifer	LFA
Undifferentiated aquifers systems and confining units		UAS/UCU

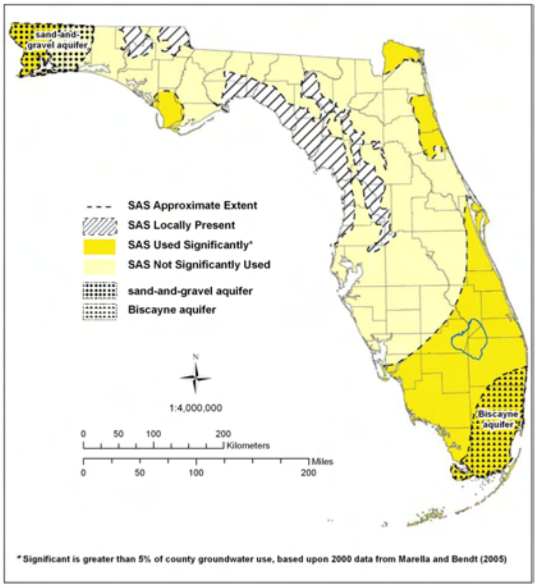


Figure 2. Approximate areal extent of surficial aquifer system and where it is used significantly (Source: Florida Geological Survey).

Intermediate Aquifer System or Intermediate Confining Unit: The IAS/ICU includes all rocks that lie between the overlying SAS (or land surface) and the underlying FAS. Collectively, the IAS/ICU slows down the exchange of water between the surficial and Floridan aquifer systems. In general the IAS/ICU consists of sands and clays intermixed with carbonate rocks. Where present, aquifers within system are only locally important. Figure 2 displays the extent of the IAS/ICU. It also shows that in southwest Florida, the IAS is a significant source of groundwater. In central Florida and in the eastern panhandle, the IAS/ICU is often absent or only locally present. In the far western portion of the state and in the southern third of the peninsula, the IAS/ICU can be over 200 feet thick.

Floridan Aquifer System: The FAS (Figure 3) underlies the entire state. It is made up primarily of carbonate rocks that can be greater than 2,000 feet thick. Where overlain by the IAS/ICU, the groundwater within the FAS is generally under confined conditions. That is, the weight of the overlying sediments places a pressure on the water. If a well is drilled into the FAS, the pressure causes the confined groundwater to rise in the well to a point in the above the top of the FAS and into the IAS/ICU. If enough pressure exists, and the well is not capped, the groundwater actually flows out of the well and onto land surface. Groundwater within the IAS/ICU also is generally under confined conditions, while that in the SAS locally can be confined. Where either the IAS/ICU or the SAS is not present, the FAS is the uppermost aquifer system and it contains the water table. Miller (1986) subdivided the FAS into the Upper Florida aquifer (UFA) and the Lower Floridan aquifer (LFA) (Table 1). The MFCU is not always present. Where this occurs, the UFA cannot be separated from the LFA and the "Floridan" is the entire FAS. The UFA is the most significant aquifer within the FAS and represents the source of water for most of the springs of Florida.

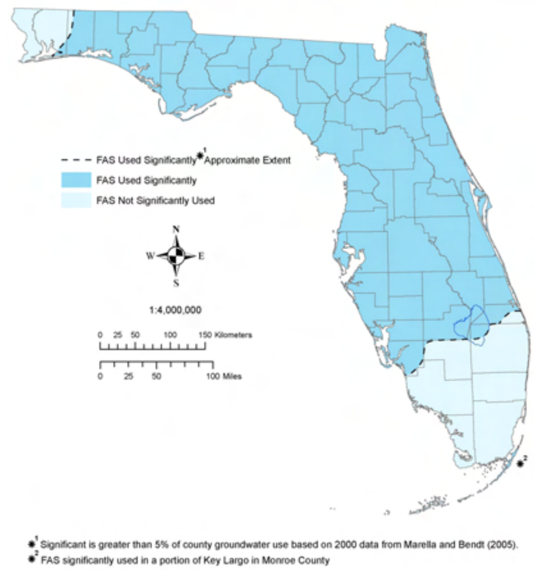


Figure 4. Areal extent of the Floridan aquifer system in Florida and where it is used significantly (Source: Florida Geological Survey).

In terms of water use it is by far the most significant aquifer system (Figure 3). In extreme western Florida and in south Florida, the top of the FAS is found deeper and deeper beneath land surface. It also becomes saltier and for this reason, it is not the primary source of groundwater. In northwest Florida, the sand-and-gravel aquifer is the primary source, while in southeast Florida, the major source of groundwater is the Biscayne aquifer (Table 1).

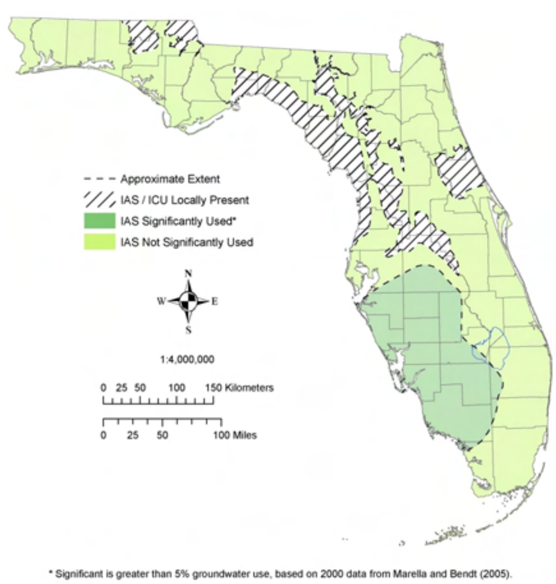


Figure 3. Areal extent of the intermediate aquifer system or the intermediate confining unit and where the aquifer system is used significantly (Source: Florida Geological Survey).

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