

Biodiversity of Indicator Species Present in Florida Friendly Ponds

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## **Abstract**

Sustainable development is an important goal for society, and is discussed by ecologists all over the world. This study tested the effects on pond biodiversity by a theoretically sustainable practice called “Florida Friendly Landscaping,” which implements a number of specifically environmentally beneficial practices to the landscaping and creation of and surrounding retention ponds in Florida. To determine if Florida Friendly retention ponds were successful, we compared the biodiversity of three retention ponds that met Florida Friendly criteria, and three ponds that did not meet the criteria, on the University of Central Florida campus. Ponds were surveyed for indicator species by means of observation for ten minutes twice per day, three times per week, for six weeks. Two minnow traps were also set in each pond, and checked before every observational surveying period. Biodiversity was then quantified using observed species and Simpson’s Index equation. In this study, Florida Friendly ponds were found to have a higher count of indicator species, but a lower measure of biodiversity – thus making the study insufficient for determining whether or not Florida Friendly landscaping is beneficial for Florida pond ecosystems. With these results, other studies may be conducted to determine if abundance of indicator species or observable biodiversity is more important when assessing the health of an ecosystem. Florida Friendly may still prove to be beneficial because of the relatively large abundance of individual organisms, but if obtaining higher biodiversity is the goal, creating Florida Friendly pond habitat may be counterproductive.

## **Introduction**

Urbanization contributes to many drastic changes in the natural world, which may affect environmental health. The development of urban areas causes habitat loss and fragmentation, increased levels of pollution entering the atmosphere and waterways, and a decrease in the number of plant and animal species that are able to survive (Hamer and McDonnell, 2008). With urbanization increasing with no end in sight, these anthropogenic-caused problems will only worsen. One way to assess the negative effects of development is to test the quality of a body of water. Pollutants such as chemicals, fertilizers, gasoline, and garbage can all end up in a city's waterways. These pollutants destroy ecosystems, and eradicate plant and animal life.

As cities and urban areas continue to grow, it becomes more important to determine the effects urbanization is having on the environment. Sets of guidelines were developed by the United States Fish and Wildlife Service in order to monitor habitat for selected species of wildlife (Landres, Verner and Thomas, 1988). These "evaluation species," were selected based on ecological criteria, such as "sensitivity to environmental factors" (Landres, Verner, and Thomas, 1988, p. 318). This method was developed into the use of indicator species in order to assess a wide variety of environmental health issues.

One major determinant of ecosystem health is the presence of indicator species, or animals that "are sensitive to environmental contaminants or habitat attributes of concern" (Landres, Verner and Thomas, 1988) which makes them excellent candidates for assessing the overall health of an ecosystem. For pond ecosystems in particular, these species can range from herpetofauna to fish because of their sensitivity to the elements

around them. This sensitivity is due to their permeable skin that can absorb toxins and other pollutants from their constant interaction with aquatic ecosystems. Because of this, indicator species are successful in assessing air and water quality (Landres, Verner & Thomas, 1988). Frog species in particular are important indicator species because of their ability to go between water and land habitats, making them an important indicator to the health of a pond ecosystem. The use of indicators to determine health is effective because if the most sensitive animals are able to thrive, then other plants and animals should also be able to do fine in these ecosystems.

In Barabasi and Bonabeau's article *Scale-Free Networks* (2003), the concept of a hub is presented; meaning the center of a network has many more connections to other components. Thinking in these terms, each pond is considered a hub, and wildlife can travel through the network of different ponds. Because of this, ponds were chosen for this project because they are partially closed hubs, and the distance between ponds makes it difficult for smaller fauna, or amphibians, to migrate between ponds. Many more factors affect frogs than most other species due to their prevalence in the food chain. Frogs can also affect many more species as well. This is why the abundance of indicator species was determined to be the most effective way of measuring the health of the pond ecosystems and how to better manage them sustainably. In order to create and maintain sustainable ecosystems, we have to at least have a basic understanding of the interconnections between indicator species and their functions related to other ecosystem functions, processes, and how they are all interdependent upon each other (Bengtsson, 1998). Knowing the connections between all ecosystem processes can lead to sustainable

ecosystem management because of the larger implications of these connections, and their impacts on our own lives and those of the organisms living in these ecosystems.

Amphibian populations have been declining worldwide, which is causing major concern for environmentalists and scientists (Nystro, et al 2007). Amphibian decline causes concern that other species of both plants and animals may decline as well, due to the water and air quality conditions that are causing amphibian decline (Nystro et al 2007). Worldwide amphibian decline has caused many advocates of the environment to want to test air and water quality to determine the sources of pollution. Urban areas are common test sites due to the heavy anthropogenic influences these areas have (Beebee and Griffiths, 2005). In Florida, urban freshwater systems are commonly tested.

Ultimately, this study is using indicator species to quantify biodiversity. The more indicator species and individuals present, the more individuals from other species may be supported by that ecosystem. For the purposes of this experiment, species biodiversity may be defined simply as “the variety and abundance of different types of organisms which inhabit an area” (Jenson et al., 1990). Biodiversity is arguably the determining factor for ecosystem health. This is because the more species present, the more niches are filled - therefore the more productive the ecosystem is. A niche is a role an organism plays in its environment (Jenson et al., 1990). It stands to reason an ecosystem is likely to collapse if certain roles are not filled. A high measure of biodiversity ensures that all necessary niches are filled so that the ecosystem may continue to function. Furthermore, greater species diversity ensures natural sustainability for all life forms because, as in all networks, everything is connected in some way. One species benefits another and if an environment was to become mono-populated it would be virtually impossible for all of

the mechanisms required to sustain a habitat to be fulfilled, resulting in the collapse of the ecosystem and any species that depended on it. It has also been determined that with high biodiversity, an ecosystem is likely to recover from a disturbance more quickly. For example, if a hurricane disrupted the natural processes of two marshes, one with high biodiversity and one with low biodiversity, the marsh with more biodiversity would recover more quickly. Once it is recovered it can continue to perform its ecological services.

Species richness is a term closely related to biodiversity – it is the number of species present. This term differs from biodiversity in that it is merely the count of species, and not the count of individuals belonging to those species. Species richness was also taken into consideration when calculating our results.

The most prevalent bodies of fresh water on the UCF campus are ponds. A pond, for the purpose of this study, is a body of fresh water that does not have an aphotic zone. Ponds are the most practical locations to test biodiversity in this study because they are relatively small and have fewer variables to control. The small size and sensitivity of these fresh water habitats make effects on water quality easy to test and pollutants easy to detect compared to other habitats. There are at least 15 ponds on the UCF campus so there are enough treatments to make any findings significant. All treatments are in relatively close in location to one another, and conditions are mostly consistent across the campus, so independent variables are less likely to be consistent in all treatments. In this study, two treatments are chosen of equal sizes that are within the same storm water quadrant (Figure 3). In this way it is known that the water that enters these ponds is of the same quality, and any differences in biodiversity and species abundance is the result of

the surrounding environment, and not of initial water quality. By controlling these variables, we can ensure that the differences are a result of the type of landscaping that surrounds the ponds.

Testing these ponds is important. If habitat degradation is detected early by testing indicator species in the ponds that are not Florida Friendly, the proper measures may be taken to prevent ecosystem collapse, and the loss of keystone species before a threshold is breached. Improving the health of the UCF ponds will improve the health of the UCF campus and improve the quality of the aquifer as well. The ponds that were tested are Florida Friendly landscaped ponds, and ponds that are not landscaped in a Florida-Friendly manner.

'Florida Friendly' refers to landscapes that protect natural resources through the conservation of water, prevention of erosion, creation of wildlife habitat, and the reduction of waste and pollution (Florida University, 2009). This type of landscaping protects the waterfront with a maintenance free buffer zone, which provides wildlife habitat. Since these buffer zones are maintenance free, there is no need to return to the sites for trimmings and alterations. The zones can encompass up to 60% of the lake and is composed of native and non-native Florida plants that can coexist with natives. The proper landscaping, and a larger buffer zone around ponds, helps to absorb and filter storm water run off before collecting within drainage sites. This natural filtering system is important for the cleanliness and purity of the water cycles – urban and natural.

Stormwater runoff usually carries pesticides and fertilizers into bodies of water, which in turn eventually appear in the aquifer (Florida Friendly Landscaping Program). Fertilizing Florida friendly landscapes, although unnecessary, is done sparingly and without

exceeding the recommended amounts. The fertilizer chosen has low nitrogen contents, and should be ones that do not harm or pollute, such as chicken manure (UCF Landscape and Natural Resources). The plants within the buffer zones surrounding the pond are planted for the purpose of preventing erosion as well as for filtration. No invasive plant species should be within the ponds perimeter, for these plants require much more water and fertilizer, which in turn is unhealthy for the water shed drainage. Florida Friendly landscaping should help the overall health and water quality of these ponds, which should in turn show more indicator species present.

‘Non-Florida Friendly’ refers to ponds that require many resources in order to keep the pond landscaped. This includes invasive plant species, manicured grass, and plants that would not naturally occur near a pond (Florida Friendly Landscaping Program). These plants require much more fertilizer and watering than native species, which is detrimental to the overall health of our aquifers and ecosystems.

Our objective was to determine whether there is more wildlife biodiversity in Florida Friendly landscapes than landscapes that are not Florida Friendly. Our hypothesis was that Florida Friendly landscapes are more ecologically sustainable, based on the presence of indicator species. Based on our hypothesis, we expected to see in our results that Florida friendly landscapes benefit the aquatic system in many ways. One example is Florida Friendly landscapes key component, “right plant right place,” which is very beneficial because native plants being placed in the right place help reduce the amount of water needed to upkeep the landscape. The reason being is that native plant life cycles benefit best from natural watering cycles (Dukes et al, 2013). Each factor is going to tie into the success of each Florida Friendly landscape and aquatic system. Therefore, we



expected opposite results from our non-Florida Friendly landscapes. We predicted that there would be limited indicator species encountered during visits as well as worse water quality and minimal wildlife biodiversity.

All in all we hoped this study would benefit the eco-system as defined by Alaina Bernard and Jennifer Elliot (2013) as the interrelated systems of the environment, the economy and the people. When the people of Florida improve their landscaping practices, the economy is strengthened by continual development and the environment is not harmed and can continue to function and provide ecological functions for the people and other species. This is how sustainable development may be achieved.

## **Methods**

The amount of biodiversity was measured by sampling indicator species in both Florida Friendly ponds and ponds that are not Florida Friendly. Each pond was surveyed on Sunday, Monday, and Tuesday, at 8 a.m. and 8 p.m. The three ponds considered “Florida friendly” landscaped ponds were compared to the three ponds that we labeled as not landscaped in a “Florida friendly” manner. The ponds that we assessed are all on the University of Central Florida campus (see Figure 4).

To begin, we placed randomly placed two minnow traps (Figure 5) in each pond. The traps were placed one foot off of the shoreline, and parallel to the shoreline. We set the traps at 8 p.m. in each pond, and then checked the following morning at 8 a.m. After recording and calculating the data, we emptied the traps and reset them for the following day.

After setting the traps, we walked the perimeter of the pond for ten minutes to observe the surrounding area for wildlife. The time of day, weather conditions, temperature, and other relevant information were documented. Vertebrates spotted within a fifteen-foot radius of the pond were recorded. Dip nets were additionally used to randomly sample species in six sectors around the perimeter of each pond shoreline within the dense vegetation to identify tadpoles and larva in the pond.

During the observation period, we listened for vocalizations of indicator species (typically frogs), and recorded the amount heard and the species. Vocalization data was collected at the 8 p.m. shifts since this was when amphibian activity was most abundant.

Data was collected for six weeks, and then analyzed to determine the biodiversity in each pond. The data from the Florida Friendly ponds and the non Florida Friendly ponds were compared in order to obtain the results. Finally, we conducted a water quality test for dissolved oxygen, nitrate, pH, and bacteria.

## **Results**

### *Indicator Species Observed*

The majority of our findings were based on observations, and at each of the six ponds, different indicator species were found. At the Florida Friendly ponds, *Lithobates sphenoccephalus* (Southern Leopard frog), *Hyla cineria* (Green tree frog), *Anaxyrus terrestris* (Southern Toad), *Osteopilus septentrionalis* (Cuban tree frog), and *Rana catesbeiana* (Bull frog) were observed, while the non Florida Friendly ponds had some of the same species but did not host *Hyla cineria* or *Anaxyrus terrestris*, but did have *Gastrophryne carolinensis* (Narrow mouth toad).

The Florida Friendly pond at Garage H proved to be the pond that had the most indicator species present. At one observation period, 56 indicator species were counted. This is a much higher number than the other ponds; 12 indicator species were counted at the Florida Friendly pond near the Arboretum, and 18 indicator species were the most counted at the Florida Friendly pond near Lake Claire. The ponds that were not Florida Friendly had a significantly lower number of indicator species observed at one time; the pond near the softball fields had five indicator species observed, the pond near the Student Union had seven, and the pond near Lake Claire had four. This number reflects the number of indicator species observed at one observation time. This is an important number to include because it gives a picture of how many indicator species could be at one pond at any given time.

*Water Quality*

The water quality of each of the six ponds was tested using an Urban Water test kit. Each pond was tested for bacteria, dissolved oxygen, pH, and nitrate. The results are as follows:

Table 1: Florida friendly pond water quality

<b>Florida Friendly</b>	<b>Garage H Quadrant 1</b>	<b>Arboretum Quadrant 2</b>	<b>Lake Claire Quadrant 3</b>	<b>Average</b>
<b>pH</b>	6	6.8	7	6.6
<b>Dissolved Oxygen (ppm)</b>	4	6	7.5	5.83
<b>Nitrate (ppm)</b>	2	3	2	2.33

Table 2: Not Florida friendly pond water quality

<b>Not Florida Friendly</b>	<b>Softball Quadrant 1</b>	<b>Student Union Quadrant 2</b>	<b>Lake Claire Quadrant 3</b>	<b>Average</b>
<b>pH</b>	6	6.5	6.2	6.23
<b>Dissolved Oxygen (ppm)</b>	6	5	4	5
<b>Nitrate (ppm)</b>	4	3	4	3.67

The bacteria at each of the six ponds all tested positive, so the data was left out of the charts. Visible in table 1, the Florida Friendly ponds had a higher pH on average compared to the not Florida Friendly ponds, visible in table 2. The Florida Friendly ponds also had a higher average of dissolved oxygen, at 5.83 ppm compared to the not Florida Friendly's average of 5 ppm. The nitrate parts per million in the Florida Friendly ponds had an average of 2.33, while the not Florida Friendly ponds had a higher average at 3.67.

The minnow traps were used in hopes of trapping indicator species, but it was generally unsuccessful. The minnow traps mostly caught small fish, crawdads, and insects. Only one indicator species was caught; a bullfrog at the not Florida Friendly pond near Lake Claire. Because of the limited number of indicator species found in the minnow traps, this method was not a major source of our data collected.

#### *Biodiversity calculations*

The numerical value of biodiversity is represented by D. The range is 0-1 and the lower the number the more biodiversity at that location. To determine this value we used the Simpson's Index equation:  $D = (\text{sum of}(n_i(n_i-1)))/(N(N-1))$

D being biodiversity,  $n_i$  being amount of individuals in a species and N representing the total number of all individuals.

Biodiversity for Florida Friendly ponds, as seen in table 3, was as follows; .629, .567, .340 with Garage H having the most biodiversity (lowest number) and Lake Claire having the least biodiversity (highest number). The ponds that were not Florida Friendly had more biodiversity, with only the least diverse pond having less biodiversity than the most diverse Florida Friendly pond. The biodiversity for the ponds that were not Florida

Friendly, as seen in table 4, was as follows; .388, .267, .269. The softball pond had the most biodiversity with the lowest number of .267 and of the not Florida Friendly ponds the Student union pond had the least biodiversity (highest number).

Table 3: Florida friendly pond biodiversity

<b>Florida Friendly</b>	<b>Garage H Quadrant 1</b>	<b>Arboretum Quadrant 2</b>	<b>Lake Claire Quadrant 3</b>
<b>Biodiversity</b>	.340	.567	.629

Table 4: Florida friendly pond biodiversity

<b>Not Florida Friendly</b>	<b>Softball Quadrant 1</b>	<b>Student Union Quadrant 2</b>	<b>Lake Claire Quadrant 3</b>
<b>Biodiversity</b>	.267	.388	.269

As for individuals counted, the Florida Friendly ponds far outnumbered the ponds that were not Florida friendly. With the Arboretum pond having 62, Lake Claire having 103, and Garage H having 305. The ponds that were not Florida Friendly did not have as many individuals with Lake Claire having 30, Student Union having 34, and the Softball field pond having 40. In total, Florida Friendly had 470 organisms observed while the other ponds totaled 104.

These were not our anticipated results. These results are complicated because even though the Florida Friendly ponds had much more abundance of indicator species and theoretically should be able to support more species, there was less biodiversity. This brings up a new question. Which is more important when judging ecosystem health; the number of individuals present or the biodiversity?

## **Discussion**

### *Indicator Species*

Florida's freshwater ecosystems are abundant with wildlife, serving as habitat to an array of fish, amphibians, aquatic mammals, birds and vegetation. These freshwater environments are imperative for the ecosystems of Florida. There are over 100 documented freshwater fish species in the South Florida region alone (Florida Museum of Natural History). According to the University of Florida the most prevalent species in Florida wetlands are amphibians. There are 78 documented species of amphibian and reptile species in Florida's freshwaters (Krysko et al., 2011) suggesting that there is diversity as well as abundance in these ecosystems.

Although these numbers may persuade some that Florida freshwater ecosystems are flourishing, the truth is that these environments are extremely sensitive. According to the Florida Fish and Wildlife Conservation Commission 2013 report on Florida's Endangered and Threatened Species there are a total of 66: fish (14), amphibians (6), reptiles (24), and invertebrates (22) that are listed as endangered or threatened. Most of these species live or directly rely on Florida freshwater habitats. Without these studies and others like them, the decline of these species is likely to go unnoticed and could lead to degradation, or collapse, of the ecosystems they participate in. That is until more dire consequences are noticed such as the inability of some freshwater ecosystems around the world to provide ecosystem services. This is most obvious where humans are most dependent on them, in the developing world. Changes in development and agriculture have caused a decline in water quality and quantity, leading to many deaths (Foley et al., 2005).

Having knowledge of the consequences and relative ease of the collapse of freshwater systems it is a wonder that virtually all freshwater environments that are in developed areas are manipulated in some way by people. Freshwater ecosystems can be affected by runoff of fertilizers, changes in surrounding vegetation and soil, presence of nonnative species and of course the manipulation of the freshwater body itself. For example, the UCF campus has been developing since 1963 and has been manipulating their freshwaters ever since (Refer to Figure 1, 2). Efforts such as Florida Friendly Landscapes have been made to lessen or even eliminate any negative impact campus development may have on the freshwater ecosystems.

This matter is of dire importance because indicator species “provide early warning of environmental impacts through natural response” (Carigan and Villiard, 2001). Although our anticipated results were not reached, the value of this project still held some integrity. Indicator species biodiversity may have been found to be lower for the chosen Florida Friendly Landscapes, but the species richness of indicator species was found to be greater for the selected ponds. According to Colwell and Gotelli (2001), species richness is “a fundamental measurement of community and regional diversity, and it underlies many ecological models and conservation strategies”. Species richness may be “the simplest way to describe community and regional diversity (Colwell and Gotellie)”, but quantifying species richness is even more important. Not only for simple comparisons among survey sites, but also for addressing the concentration of local communities colonized from regional hubs. As Colwell and Gotelli state, “maximizing species richness is often an explicit or implicit goal of conservation studies”.

Through hours of observations, it was theorized that “right plant, right place” played an important role in indicator species richness. We observed many correlations between certain indicator species (frogs) and certain species of plants. No previously written documentation of these specific correlations were found, so we are relying solely on our own observations of these specific species and their specific placements around UCF’s storm water ponds. At garage H, it was observed that green tree frogs (*Hyla cinerea*) were amongst the most prolific of the indicator species, this also happened to be the only pond where *H. cinerea* was observed. During both our daytime and nighttime visits to Garage H, the majority of the *H. cinerea* found were on or around the branches and leaves of star anise (*Illicium verum*). This also happened to be the only pond where *I. verum* was present. It was also observed that *I. verum* leaf color was very similar if not identical to the normal color expressed by *H. cinerea*. This with the combination of being the thickest of foliage was believed to create the optimum micro-habitat for *H. cinerea*.

Other correlations were observed as well, one being the correlation between pickerel weed (*Pontederia cordata*) and the abundance of southern leopard frogs (*Lithobates sphenoccephalus*). *L. sphenoccephalus* was the most commonly observed indicator species, but the highest densities of *L. sphenoccephalus* were observed along ponds where *P. cordata* present. Our theories for this being that *P. cordata*, provided optimum shelter from harsh sun and predators for *L. sphenoccephalus* and possibly a place for propagation since, freshly metamorphasized individuals were found near *P. cordata*. Correlations between southern toads (*Anaxyrus terrestris*) and wire grass (*Arstida stricta*) were also noted.



Indicator species are important when considering human impacts on our environments and the further correlation to sustainable action. When we release pesticides and fertilizers and other toxins into our environments, they get washed away into our water systems, and subsequently, pond systems. These pollutants degrade our water systems by creating a poor water quality that many plants and animals cannot thrive in. This destroys ecosystems, beginning with indicator species and working its way up to affect other species. Consequently, the biodiversity of these systems is lowered and suffers because it is no longer healthy enough to support multiple species. Worldwide amphibian decline has caused many advocates of the environment to want to test air and water quality to determine the sources of pollution. Urban areas are common test sites due to the heavy anthropogenic influences these areas have (Beebee and Griffiths, 2005). In Florida, urban freshwater systems are commonly tested.

### *Water Quality*

The aspects of water quality were chosen because they were the most indicative of the overall water quality of the ponds that we were observing. The first test, nitrate, was performed to determine if there were high amounts of waste or chemicals in the water. Nitrates typically enter water systems through fertilizer runoff and while nitrogen is important for plant growth, high levels of nitrogen are detrimental because it stimulates the growth of algae and cyanobacteria. This causes hypoxic conditions that can lead to eutrophication (Briand et al., 2003). This begins to absorb and take the oxygen out of the water; slowly killing off all other animal life in the water, including plants on the pond floor that are unable to get sunlight after algae creates a surface cover. For the tests that were performed, nitrate levels fewer than four are considered to be healthy for freshwater

systems and are desired in order to maintain a healthy aquatic system. On average, the Florida Friendly ponds that were tested showed healthier nitrate levels than the Non-Florida Friendly ponds. This could possibly be attributed to the Florida Friendly ponds having more plants and landscaping around the perimeter of the pond and the edges of the water that could help to filter out high levels of minerals and toxins out of the water. The Non-Florida Friendly ponds also had higher population levels of fish, which could be responsible for increased waste that could increase nitrate levels.

The next test was for the dissolved oxygen levels in the ponds. According to the U.S. Geological Survey, in aquatic systems, flowing water has higher dissolved oxygen levels than stagnant water because the flowing and rushing of the water allows oxygen to mix in and creates better circulation throughout the system (Perlman, 2013). However, since ponds are stagnant ecosystems, maintaining a healthy dissolved oxygen level can be a challenge. A dissolved oxygen level around 5 is required for the growth of aquatic systems. However, when algae blooms and bacteria are abundant, or when organic matter decays in the water, this uses up the available oxygen and chokes any other surrounding plants or animals trying to live in the pond. Without sufficient levels of dissolved oxygen, life in pond environments cannot be sustained and will die off because aquatic plants and animals require dissolved oxygen in the water to survive.

The third test was for pH to determine how soluble nutrients in the water are, and therefore how much can be taken up or absorbed by organisms in the water. A high pH creates nutrient deposits in the water whereas a low pH causes nutrients to dissolve into the water (Perlman, 2013). Seeing as pollutants and other toxins can alter the pH of aquatic systems, this can also help to determine the solubility of these pollutants in the

water, and therefore how much of this is being absorbed by organisms in the water, which can cause health problems and is also a major stressor on animal and plant life in general (Bonga, 1997). An average pH of 7 is required to healthy freshwater ecosystems. More importantly, a stable pH is preferred because organisms in the water become accustomed to these levels and a slight change in either direction can cause health problems for fish or plant life, possibly sending them into shock. The pH of all of the ponds tested was adequate, however, on average, the pH of the Florida Friendly ponds was closer to the optimal level of 7 than the average pH of the Non-Florida Friendly ponds.

These three tests were important in indicating the water quality and overall health of the aquatic pond systems that we observed because they build off of an effect each other. For example, typically poor nitrate levels cause lower dissolved oxygen levels, which will lower the pH, and this will be harmful to anything interacting in the water. This happens anytime pollutants such as fertilizers or other chemicals enter the water, causing high nutrient loads that create or add to poor water quality and adding to an unhealthy ecosystem which disrupts the entire ecosystem cycle, including water and nutrient cycling (Fenn et al., 1998). Because indicator species, such as frogs, have permeable skin that they can breathe through, the health and abundance of their populations is typically a good indicator of pond health because unhealthy ponds will have detrimental effects on frog populations. This has a domino effect on the entire ecosystem by altering population after population, disrupting the food chain of the pond, and killing off the majority of the species until the pond too may die.

From our results, the average nitrate, dissolved oxygen, and pH levels from the Florida Friendly ponds were healthier than the Non-Florida Friendly ponds. This could possibly be attributed to the types of plants surrounding the ponds at the edges of the water that helped to filter the water and maintain an adequate water quality. Interestingly, the Florida Friendly pond in quadrant 1, which had the highest observed number of indicator species, also had one of the lowest levels of dissolved oxygen. This usually results from an excess of organic waste or algae growth. However, seeing as this pond also had a relatively healthy nitrate level, it is more likely that this particular pond had a high oxygen demand that caused the dissolved oxygen to drop so low.

A water quality test that should have been completed was the test for phosphorus levels in the ponds. Testing for phosphorus is important because, like nitrogen, it is a nutrient that is desired for plant growth however, in large amounts it leads to algal blooms and can cause eutrophication and hypoxia in ponds. Phosphorus also typically enters water systems through runoff of fertilizers or other pollutants. Again, similar to nitrogen, certain levels of phosphorus are required in freshwater systems for life to thrive. However, it is when these levels get too high that dangers arise.

Although we believe our data to be accurate, relevant, and useful to our experiment, there were some minor flaws that occurred. If this experiment were to be conducted again, these items would be taken into consideration to result in a better overall experiment.

First, frogs and toads are most abundant during spring. It is predicted that more indicator species would have been observed if this experiment was conducted during the spring. Also, frogs are ectotherms. This means that they rely on the surrounding

environment as a heat source. During our experiment, the weather varied. Some days it was as hot as 90 degrees Fahrenheit, and other days it was as low as 50 degrees Fahrenheit. We believe this skewed our results; we might have seen more indicator species if the temperature was constantly hot. This is another reason this experiment would be more successful in the spring months.

Another factor that affected our experiment was the way we placed our minnow traps in the ponds. As stated before, two traps were placed in each pond, in random places, parallel to the shoreline. A better method would have been to place all of the traps in a pond at once, and rotate the traps each week. We believe this would have yielded more indicator species. We also believe that baiting the traps would also give more results.

Because our data was based primarily on observations, there is an amount of human error that occurred. Even though we went in pairs to observe each pond to ensure consistency, it is likely that not every single indicator species was counted. There may have been some that we failed to see or identify correctly. There was also limited access to the perimeters of the ponds. Some ponds had heavy vegetation while other ponds were simply too big to cover the entire perimeter in our allotted ten minutes of observation. This resulted in observations being taken around the same parts of the ponds each time. Because of this, we are unsure if there are more or less indicator species present at the parts of the ponds that were not observed. However, we still believe that our data is relevant because our methods were consistent throughout our experimentation.

## **Conclusion**

Returning to the earlier question of, ‘Which is more important when judging ecosystem health; the number of individuals present or the biodiversity?’ Both aspects are equally important. The number of species needs to be taken into account, but also the individuals of these species. Just because there are a few individuals of each species does not necessarily mean that ecosystem is healthier than one with many individuals of a couple different species. Both of these aspects need to be taken into account when judging the health of an ecosystem.

If indicator species populations are degrading, this is a cause for alarm concerning the health of the entire ecosystem and all that it supports. Negative impacts on communities of indicator species in a pond environment “can have potentially long-lasting implications for higher-level consumers such as wading birds” (Main, Ceilley & Stansly, 2007) that will be affected from any alterations that will take place after a disturbance in a lower animal community reaches its way up to the larger animal communities. Essentially, indicator species have become “useful for detecting changes in overall habitat structure and complexity” (Theel, Dibble & Madsen, 2008). If more effort isn’t put into the preservation of these seemingly small and unimportant species and our fresh water supplies, a domino effect will take place, quickly passing through the food chain until it reaches human kind – negatively affecting agriculture, the livestock industry, and finally reaching our vital water sources.

## Appendix



Figure 1: The UCF campus in 1963.



Figure 2: The UCF campus in 2012

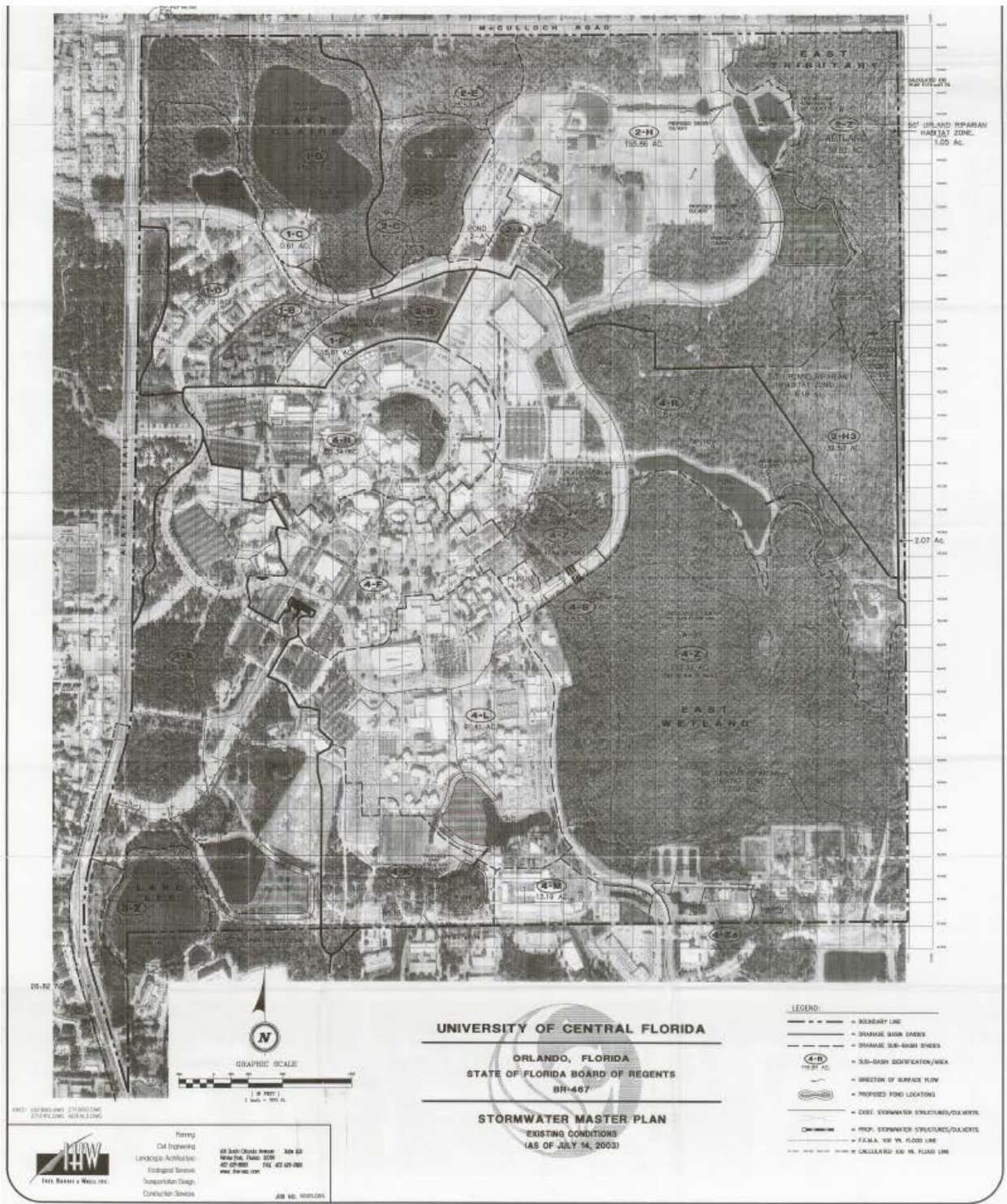


Figure 3: The UCF stormwater quadrants





Figure 4: Florida Friendly landscaped ponds are highlighted in green, while not Florida Friendly landscaped ponds are highlighted in red.



Figure 5: Example of minnow trap that was used

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