OKEECHOBEE ISOLATED WETLANDS:
INFLUENCES OF HYDROPERIOD ON PLANT SPECIE NATIVENESS IN IMPROVED PASTURE RANCHLANDS.

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ABSTRACT

The Lake Okeechobee agroecological watershed has been identified as a contributor to eutrophication of the lake and numerous efforts and Best Management Practices are being implemented to meet the target phosphorus (P) Total Maximum Daily Load (TMDL). The Okeechobee Isolated Wetlands (OIW) project was conducted to evaluate and test the potential of hydrologically restored isolated wetlands to stabilize and treatment P. However, changing wetland hydroperiod will also likely impact plant species composition and a means to evaluate changes in herbaceous cover in response to hydrologic restoration was needed.

Using a rapid digital photographic field assessment methodology first developed for underwater surveys of coral, a visual basic random point count program was used to quantify vegetative composition in isolated wetlands along a hydrologic gradient in 2004 and 2005. Vegetation species data were then compared to hydrologic stage data to determine the flooding tolerance of different species. Species nativeness was significantly related to hydroperiod in this study and indicated a clear trend that Florida native species had higher hydroperiod tolerances than non-native species. Overall, the study has shown a strong influence of hydroperiod on vegetative community composition in isolated wetlands of improved ranchlands and provides at least a preliminary means of quantifying impacts of hydrologic restoration on isolated wetlands in this region.

INTRODUCTION

The Lake Okeechobee watershed has been heavily studied and evaluated for its ecological importance to sport fisheries within Lake Okeechobee, tourism, agriculture and its influences on the Greater Everglades (GE) ecosystem (Figure 1). Federal, state and municipal policies are being implemented to control excessive phosphorus (P) runoff and leachate from urban areas, improved ranchland and dairy operations (Capece et al. 2007, Dunne et al 2007, and Smith 2006). Dairies and cow-calf cattle operations are large contributors to phosphorus loading to the lake and its tributaries (US EPA 2006, LOPP 2000). As a macronutrient, phosphorus is needed for healthy forage and animal productivity and historically was heavily applied in the watershed; however runoff of phosphorus fertilizer and the continued release of "legacy" phosphorus from the soils have led to the anthropogenic eutrophication of Lake Okeechobee (Brady and Weil 2002, Steinman et al. 2003, McKee 2005).

Figure 1. The Greater Everglades ecosystem (Hillbery 2006).

Some believe that ranches are the cause of non-point source pollution to the lake and therefore feel that they should pay for the environmental degradations caused by their agricultural practices or not be allowed to continue operations in the watershed. However, others believe that these rapidly diminishing ranchlands can serve society both for agricultural production as well as newly recognized environmental services such as water storage, wildlife habitat and nutrient retention of legacy phosphorus (Main et al. 2004, Lynch et al. 2005, Lynch and Shabman 2007, Weekly 2009). These valuable agricultural lands have narrow profit margins and could become non-profitable if more stringent governmental guidelines to address phosphorus loads are required without any ability for the rancher to pass cost on to consumers or be cost shared with the public. This would likely result in the selloff of agricultural lands in the Okeechobee watershed, as has been common throughout much of Florida as development pressure and lucrative land values make it difficult for the rancher to justify diminishing profit margins. This potential for displacing ranches for residential development would bring urbanization and sprawl which provides little benefit to the environment and could potentially be a larger contributor of nutrients and pollutants to the ecosystem that is trying to be protected (Rushton 2001, Main et al. 2004, Boughton 2008). The question becomes how to keep the ranchlands while mitigating the effects of phosphorus in the Lake Okeechobee watershed.

Florida Ranchlands Environmental Services Project

In part following the research of the Okeechobee Isolated Wetlands project and in a new approach to dealing with these environmental issues in the region, a collaboration between private, state and federal agencies was formed. In 2005, The *Florida Ranchlands Environmental Services Project* (FRESP) was proposed by the *World Wildlife Fund* (WWF) with the help of the

South Florida Water Management District (SFWMD), USDA *Natural Resources Conservation Service* (NRCS), *Florida Department of Environmental Protection* (FDEP), *Florida Department of Agriculture and Consumer Services* (FDACS) and private land owners (Lynch and Shabman 2007). This innovative project integrated with existing governmental programs like the Comprehensive Everglades Restoration Plan (CERP) and Lake Okeechobee Protection Plan (LOPP) for furthering the protection of the Greater Everglades ecosystem (Woods 2008).
The project evaluated the feasibility of providing public monies for three forms of ecological or environmental services (Lynch et al. 2005). The FRESP goals were to: 1) increase the potential of water storage on ranchlands to prevent overly pulsing and flooding the Lake Okeechobee system with more nutrients, 2) increase the amount of phosphorus retention in wetland soils by preventing excessive leaching (retaining vs. releasing P in the biogeochemistry of the local landscape), and 3) increase wetland habitat vegetative species on these ranches in question (Steinman 2003, Lynch et al. 2005, Lynch and Bohlen 2006, Lynch and Shabman 2007). The FRESP concept has now become the Northern Everglades Payment for Environmental Services (NE-PES) program which is being implemented by the South Florida Water Management District in partnership with FDACS

Factors Influencing Plant Communities

There are many factors that influence plant communities. Influences from abiotic and biotic factors do not always favor a particular species, a population, a community of species, and so on (Miller 1998, Lenssen et al. 2000). Since all vegetation is autotrophic, the abiotic or non-living components influencing plants like climate, temperature, light, nutrients, water, soil, seasonality and even space to grow are all crucial to plants (Wetland Training Institute 1995, Philippi et al. 1998, Raven et al. 1999, Brady and Weil 2002). The biotic realm of influences gets even more complex when considering competitive interactions such as space or nutrient availability as well as interactions with other species such as herbivores and plant pathogens (Raven et al. 1999). All these considerations are taken into account and support the Principle of Population Dynamics. According to Miller, the Principle of Population Dynamics states, "the size, growth rate, age structure, density, and distribution of a species' population are controlled by its interactions with other species and with its nonliving environment" (1998). Teasing apart biotic interactions can be observed with a species presence/absence experimentally, whereas the abiotic or physical environmental details of a vegetative species or natural community will take much more effort to ascertain.

Very likely the most important abiotic factor for wetland vegetation is the degree to which hydrology influences a particular site, since the occurrence of anaerobic conditions, subsequent development of hydric soils, and selection of wetland adapted vegetation are directly related to the hydrologic characteristics of a site (Brady and Weil 2002). Hydrophytic vegetation, "growing completely submerged, partially submerged, or with their roots in soil that is saturated with water for a portion of each year" (Cox 2002), have many adaptations that facilitate their respective hydrophilic niche or hydrologic regime needs, whether reproductively, physiologically, and or morphologically (Wetland Training Institute 1995). Because hydrophytic vegetation has different tolerances to the depth, duration , frequency or timing of inundation, the distribution of species along an elevation gradient can be utilized as a potential indicator of a wetlands hydrology (2002, van der Valk 2006). The Range-of-Tolerance Principle (each species and each individual organism can tolerate only a certain range of environmental conditions) and the Limiting Factor Principle (too much or too little of a physical or chemical factor can limit or prevent the growth of a population in a particular site) both further support this thought (Miller 1998). This central concept for wetland vegetation serves in part for wetland delineations used by many agencies (Wetland Training Institute 1995, National Wetlands Inventory 1996). This thesis aims to quantify the relationship between plant community composition and hydrologic conditions (or the driving factors of hydrology) occurring in geographically isolated wetlands in the Lake Okeechobee watershed.

Hydroperiod vs. Hydropattern

Hydrology of a wetland can be described by two terms, hydroperiod or hydropattern (van der Valk 2006). Hydroperiod is the simpler description of environmental hydrology and represents the total number of days in a year that a particular wetland or location in a wetland is flooded (Cronk and Fennessy 2001, Brady and Weil 2002, Whitney et al. 2004). In some earlier descriptions of hydroperiod, it may also be reported in terms of months or even as a percentage of a year (Myers and Ewel 1990). The characteristics or factors of frequency (average or number of floods) and duration (length of flooding) of the flooding or inundation period(s) together define the hydroperiod which is usually displayed in hydrographs (graph of relative water levels compared to time) (Mitsch and Gosselink 2000, van der Valk 2006, Reddy and DeLaune 2008). Most studies refer to a site's hydroperiod since the water budget for hydropatterns can be more difficult to quantify.

The more complex description of wetland hydrology is termed hydropattern (Tiner 1999). This description takes into consideration five hydrologic factors. They are the seasonality (timing), flow (rate of change), depth (magnitude), frequency and duration of the flooding of a particular site (Richter et al. 1996, van der Valk 2005, Reddy and DeLaune 2008). Since wetland hydrology is a fundamental factor of wetland development, it could be further surmised that the species present would therefore be specialist to specific hydrologic regimes (Wetland Training Institute 1995, Miller 1998). Understanding this relationship will further help land managers protect species diversity and manage ecological integrity (Miller 1998). In this study, the use of wetland hydroperiod will be defined along with species nativeness.

Species Nativeness

Understanding species origins is extremely important when considering management of natural ecosystems and the employment of conservation biology (Miller 1998, Silk and Ciruna 2004). Native species can be thought of as species that have originated or speciated in a particular area or region. They are also commonly referred to as indigenous (from the area) or endemic species (found only in a specific area) (Whitney et al. 2004, Langeland et al. 2008). Other species that have recently migrated or those that were introduced into a new area where they have not originally lived are known as non-native, exotic, alien or introduced species (Miller 1998, Langeland et al. 2008). Many nonnative species are also labeled as invasive species, but note; native species can also be invasive species as in weeds or a species without its keystone grazer/predator (Miller 1998). According to Whitney et al. (2004), invasive species are those that can reproduce rapidly, displace the ranges of other species and are detrimental to local food webs.

Besides those species that were introduced into a region and managed specifically for agricultural production, most nonnative species come with negative environmental ramifications. Nonnative species are such a concern that there are many rules, regulations, orders and treaties that govern species at the state (FAC Chapter 62C-52.011: Florida Prohibited Aquatic Plants), national (Nonindigenous Aquatic Nuisance Prevention and Control Act, President Clinton Executive Order 13112-1999: creation of the National Invasive Species Council) and even international (International Plant Protection Convention of 1951) level (Ciruna 2004, Kaufman and Kaufman 2007). Private citizens and groups have even formed to help educate the greater public about the environmental cost of non-native species with groups like the Exotic Pest Plant Councils (Whitney et al. 2004, Langeland et al. 2008). This validated concern is due to their region of original speciation where they likely had a form of biological, chemical, and or physical control which kept their population in some degree limited in numbers. Nonnative species spreading uncontrolled in a new host ecosystem are then poised to threaten biodiversity as seen in the south Florida Greater Everglades (Myers and Ewel 1990, Ciruna 2004).

Approximately 42% of the native flora and fauna species protected by the Endangered Species Act of 1973 are at risk from nonnative species (better described as invasive alien species or IAS) that are displacing them in their native ranges (Ciruna 2004, Pimentel et al. 2005). Prevention of their introduction is key since the activities of eradication or management come with great cost. For example, the management of one aquatic IAS, hydrilla (*Hydrilla verticullata*), in Floridian waterways cost the state ~$14.5 million annually (Pimentel et al. 2005). Understanding species nativeness is of utmost concern when considering land management (uplands to lowlands) strategies when considering the eradication or management of these disturbed areas where nonnative species are colonizing.

Research Hypothesis

It has been hypothesized that if hydrologically modified wetlands are allowed to reflood to historical levels, the biogeochemical processes within these wetland communities will reduce P loads in runoff water from ranchlands along with restoring native plant communities. This paper aims to quantify the relationship between hydrology and plant communities within these geographically isolated wetlands as a factor of their nativeness. In this study, wetland hydroperiod will be used to define the hydrologic condition and nativeness will be used to describe the vegetative community. The specific hypothesis to be addressed is:

- **(H_1)** vegetation nativeness (native vs. non-native) occurrence will be inversely related to hydroperiod.

MATERIALS AND METHODS

Study Sites

In conjunction with an existing monitoring program, four historically and morphologically similar isolated emergent marsh wetlands were monitored on two cow-calf operations within the Lake Okeechobee watershed (Balcer 2006, Dunne et al. 2007b, McKee 2005, Smith 2006). These two ranch locations fall within two priority basins: (S-65D and S-154) Figure 2. (Dunne et al. 2007b). These basins contribute a large amount of P to Lake Okeechobee when compared to their respective land areas of which 64% is actively used for agriculture (Dunne et al. 2007a). Today, these wetlands are ditched and partially drained. Each ranch is located in Okeechobee County, Florida roughly ten miles northwest of Lake Okeechobee. They are located within the improved pastures of the Pete Beaty Ranch and the Larson-Dixie Ranch. The ranches have considerably different cattle stocking rates at 0.5 cows per hectare on Beaty and 1.0 cow per hectare at Larson with the grazing intensity noticeably stronger at Larson (Dunne et al. 2007).

The Beaty Ranch is located within the S-65D basin (N 27º24.665’, W 80º56.940’). The two wetlands are known as Beaty North (1.5ha) and Beaty South (1.1ha). Site soils were identified as sandy, siliceous, hyperthermic Typic Humaquepts in the Placid series (Lewis et al. 2001).

The second set of wetlands is located within the S-154 basin on Larson Ranch (N 27º20.966', W 80º56.465'). They are known as Larson East (1.1ha) and Larson West (2.2ha). These two isolated wetlands are slightly larger than those found at the Beaty Ranch. Site soils were identified as siliceous, hyperthermic Spodic Psammaquents in the Basinger series (Lewis et al. 2001). The two ranches (Figure 2) and their wetlands are shown (Figure 3).

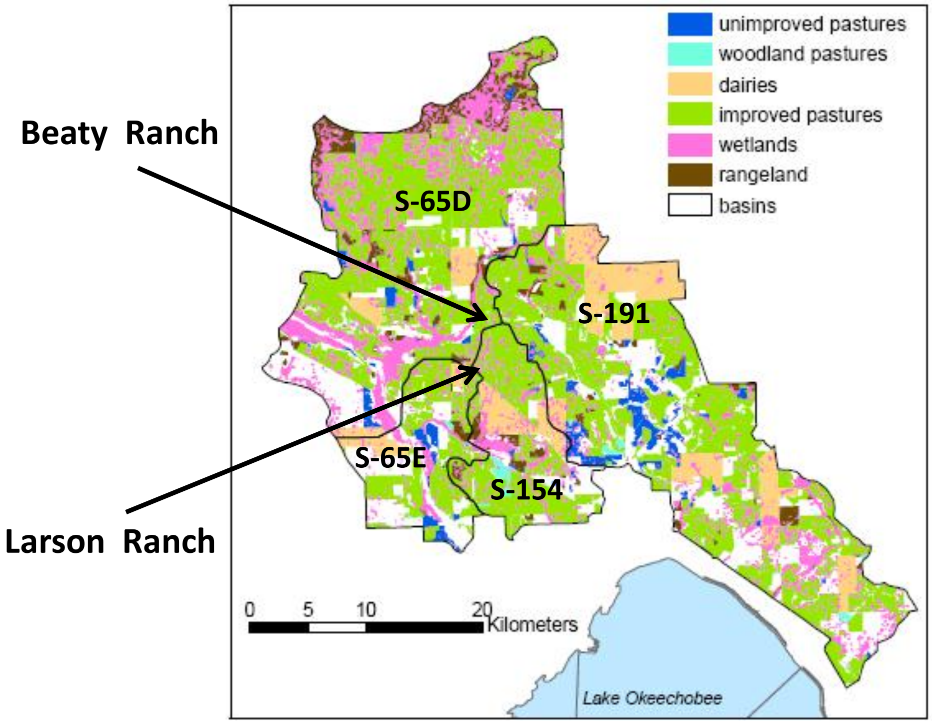


Figure 2. The four priority basins, their respective land uses in 2001 and the two ranch research sites (SFWMD 2003).

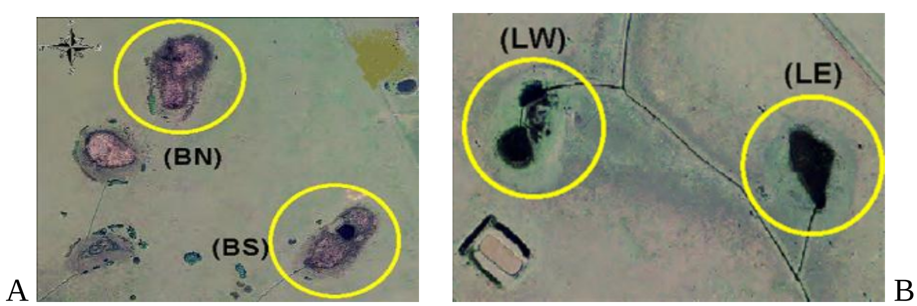


Figure 3. a.) Beaty North (BS) and Beaty South (BS) wetlands. b.) Larson West (LW) and Larson East (LE) wetlands (Dunne et al. 2007b).

Field Sampling

Permanent vegetation transects were set up from the center of the wetlands through the fringing ecotones and into the adjacent upland grazing environment of the four wetlands. Three transects at roughly equidistant azimuths were established at each of the wetlands in 2004. The wetlands were sampled once per year for two years (2004, 2005) in the summer growing season. A pictorial dataset of encountered local flora was maintained to facilitate future identifications of unknown plants and a field log ground truthed the present species.

To ensure the exact transect location was selected repeatedly, a PVC post was secured in the center of the wetland at the confluence of the three transects and a 60cm section of rebar was driven into the soils at the upland end of each transect and coordinates of the rebar location were recorded. Follow up visits to the site used a handheld Trimble GeoXT GPS unit and a metal detector to locate the transect end point. Transects varied in length from 115 - 175 meters at the Beaty wetlands and 105 – 115 meters in length at the Larson wetlands (Figure 4). Two 100 meter measuring tapes were laid out end to end between the center origin and the upland end point of the transect. During sampling $1m^2$ quadrates were positioned every five meters along the transect with the lower left hand corner at the start of the whole number to be measured. Quadrates were laid parallel to the transect tape. A pressure transducer was located at the deepest point in each of the wetland centers to record hydrologic stage data which was then used to determine the hydroperiod at various elevations within the wetland. .

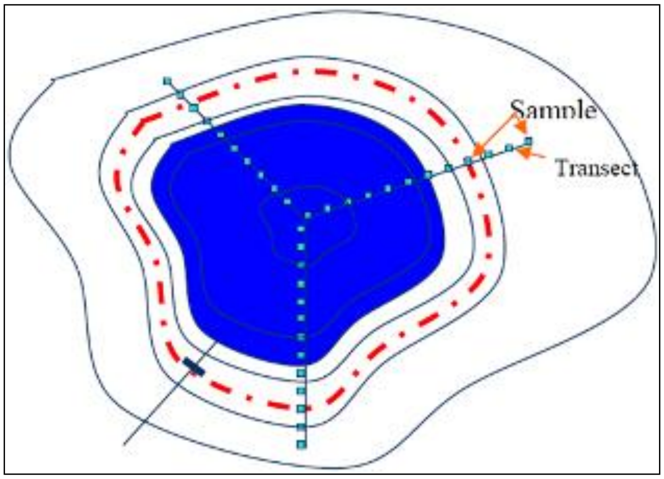


Figure 4. Vegetation monitoring design showing three transects and meter square sampling stations occurring every five meters (FRESP 2005).

During each sampling event, photographs were taken at five meter intervals along each transect using a quadrapod camera mount (Figure 5). The camera, a Sony CD Mavica 3.3 megapixel camera, was mounted two meters above the $1m^2$ sample quadrates and an image of the herbaceous vegetation was captured for analysis at a later time. In a field log, picture number, sampling site, transect number, distance from center, and the top three dominant vegetation species present were identified.

Figure 5. Set-up of the quadrapod used for photo documentation. Note the quadrapod setting protocol for the quadrate which is set onto the left side of transect tape.

Photographs were later analyzed in the laboratory using a software program called Coral Point Count with Excel extensions. Originally designed for use in monitoring coral reef communities where divers had limited time on the bottom, this visual basic random point count methodology program was created to facilitate field efficiency and document the monitored reefs (Kohler and Gill 2006). As applied here, the program was modified from coral species to herbaceous species by creating an herbaceous species attributes table for use in south-central Florida ranchlands.

Photo interpretation was conducted by initially having the CPCe program randomly assign 30 points within the virtual sample quadrate projected on the photograph and then the program user must assign a value for each point based on the vegetation species present or substrate type (water, litter, soil, or cow patty for example). An example of the point overlay and classification codes can be seen in Figure 6. A "zoom-in" feature is available to get a closer look at dark areas or small subjects if needed.

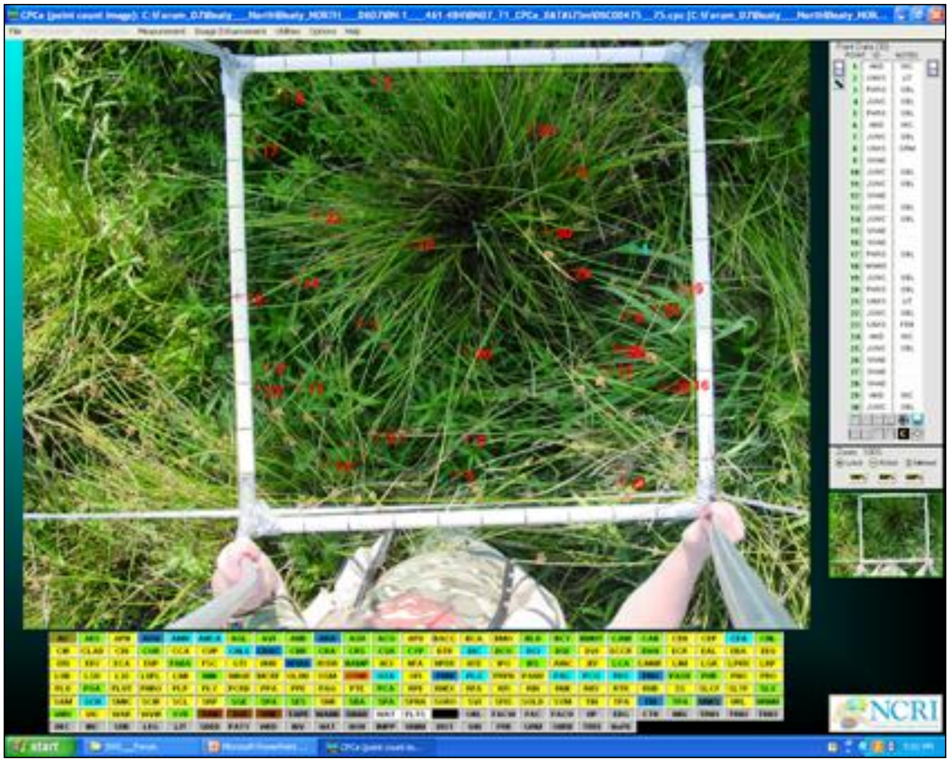


Figure 6. A screen capture from CPCe showing the 30 randomized points for the quadrate, the point data ID and NOTES in the right-side tool bar, and the bottom color coded identifiers.

In addition, a photographic library of known plant species oriented in a manner similar to that observed in the sample photo was often used to assist in species identification. The photographic library specimens were collected from the field after being photographed and identified and were saved as a voucher herbarium for later confirmation of species, if necessary. After the 30 randomly placed sample points were classified, the CPCe program calculated basic descriptive statistics for the quadrate including: species/substrate types, relative abundances, means, standard deviations and errors, plus a calculation of the Shannon-Weaver diversity index.

A preliminary assessment to optimize the number of points necessary to evaluate was conducted in accordance with the central limit theorem (Freund and Wilson 2003).

Hydroperiod Determination

Hydroperiod for each quadrate sampling site was calculated by first determining the sample site elevation relative to the water level stage recorder in each wetland, and then using the relative stage offset to determine the number of days that a particular site was inundated. Sample site relative elevations were determined using a tripod mounted laser level, Lasermark Model #LMH-GR by CST/Berger of Watseka, IL.

A 12-month antecedent hydroperiod was calculated for each vegetative assessment period during the study. This period of record was thought to sufficiently represent the effect of hydrology on longer lived perennial species, as well as capture the short-term response of annual and seed bank species during drawdown periods. Table 1 indicates the actual periods of time used to calculate the antecedent hydroperiods. Figure 7 shows the maximum period of site inundation for each study wetland on the two ranches, where the Beaty Ranch wetlands were wetter longer than the Larson Ranch wetlands. Of the two sampling timeframes, 2005 was the wetter year for 3 of the 4 wetlands overall.

Table 1. The stage antecedent hydroperiod dates used for establishment of plant hydroperiods.

Ranch	Wetland	Antecedent Year 2004	Antecedent Year 2005
Beaty	North	August 24, 2003 thru August 23, 2004	July 9, 2004 thru July 8, 2005
Beaty	South	August 24, 2003 thru August 23, 2004	July 9, 2004 thru July 8, 2005
Larson	East	August 23, 2003 thru August 22, 2004	July 27, 2004 thru July 26, 2005
Larson	West	August 22, 2003 thru August 21, 2004	July 9, 2004 thru July 8, 2005

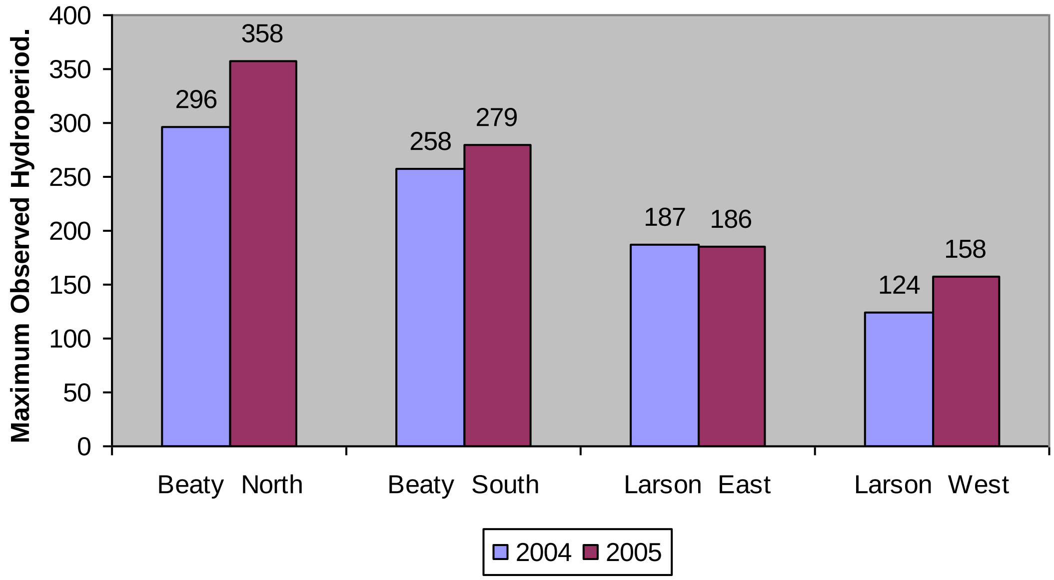


Figure 7. The maximum annual antecedent hydroperiod determined for each study site.

Data and Statistical Analysis

Due to the great number of spreadsheets generated from the pictorial analyses performed in the CPCe software, and to provide a meaningful form of data management for statistical analysis, Microsoft Excel spreadsheets were utilized as a database (Microsoft 2007). For this study, the CPCe software's ability to multitask a single set of inputted data was invaluable (Kohler and Gill 2006). SAS – JMP statistical discovery software Version 7.2 was further used to explore the large dataset and provide summary statistics for the evaluated hypotheses (SAS 2007).

RESULTS AND DISCUSSION

Over the two years of photo interpreted data collected for this study, a total of 576 pictorial quadrates were analyzed. Within those quadrates, a total of 30 randomized points were evaluated totaling 17,280 total points referenced for data analysis. Table 2 provides a summary of the combined ranch wetlands, transects and number of observations described.

Table 2. Ranch wetlands and number of transects sampled for each antecedent hydroperiod year of 2004 and 2005.

	Transect-1		Transect-2		Transect-3	
Ranch	Quadrate #	Obs #	Quadrate #	Obs #	Quadrate #	Obs #
Beaty North	*24*	720	*24*	720	*24*	720
Beaty South	*35*	1050	*26*	780	*19*	570
Larson East	*23*	690	*23*	690	*23*	690
Larson West	*21*	630	*23*	690	*23*	690

	2004	2005	Total
Quadrates	*288*	*288*	*576*
Observation	8640	8640	17,280

Species Nativeness Along a Hydrologic Gradient

At the Beaty and Larson Ranches, both sites showed a significant difference between native species and the non-native species. The Beaty native species had a mean hydroperiod of 165 days and the non-native species had a mean hydroperiod of 31 days as shown in Figure 8. Of the total 317 vegetation samples measured in this study, 172 were natives and 145 were non-native species.

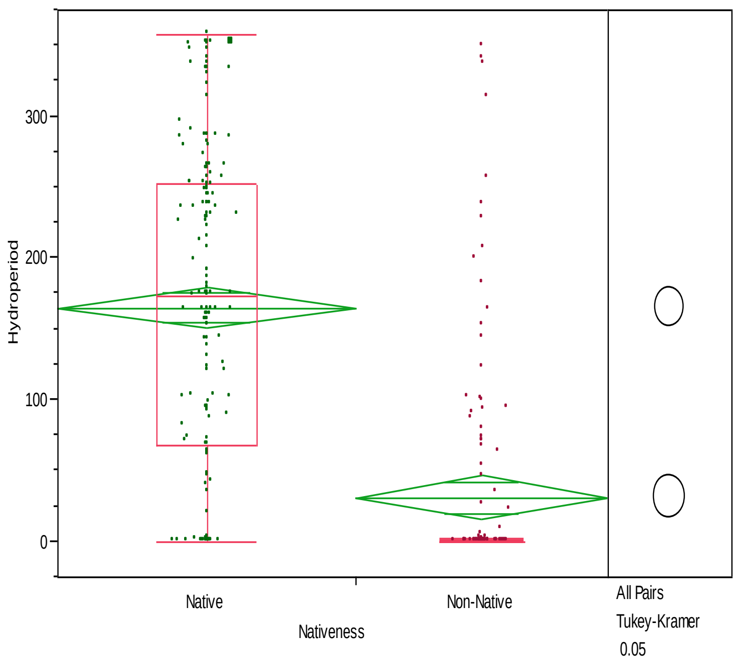


Figure 8. Hydroperiod and species nativeness for Beaty North and South wetlands.

The Larson Ranch native species had a mean hydroperiod of 58 days and the non-native species had a mean hydroperiod of 31 days. Even though the total hydroperiod spread is narrower at the Larson Ranch, the Tukey-Kramer HSD test still indicated a significant difference in the samples from the wetlands (Figure 9). Of the total 354 vegetation samples identified, 150 were natives and 204 were non-native species. In an effort to illustrate the hydroperiod difference between the two sites, Figure 9 is also set to a maximum 375 day hydroperiod to show the limited hydroperiod expressed at the Larson wetlands on the y-axis.

In Figure 10, the combined or total dataset for the study for nativeness is indicated. The overall native species had a mean hydroperiod of 115 days and the non-native species had a mean hydroperiod of 31days. Of the total 671 vegetation samples identified to the species level, 322 were natives and 349 were non-native species (a 47% to 53% ratio respectively). Again, the Tukey-Kramer test is shown to be significant throughout this study (<0.0001).

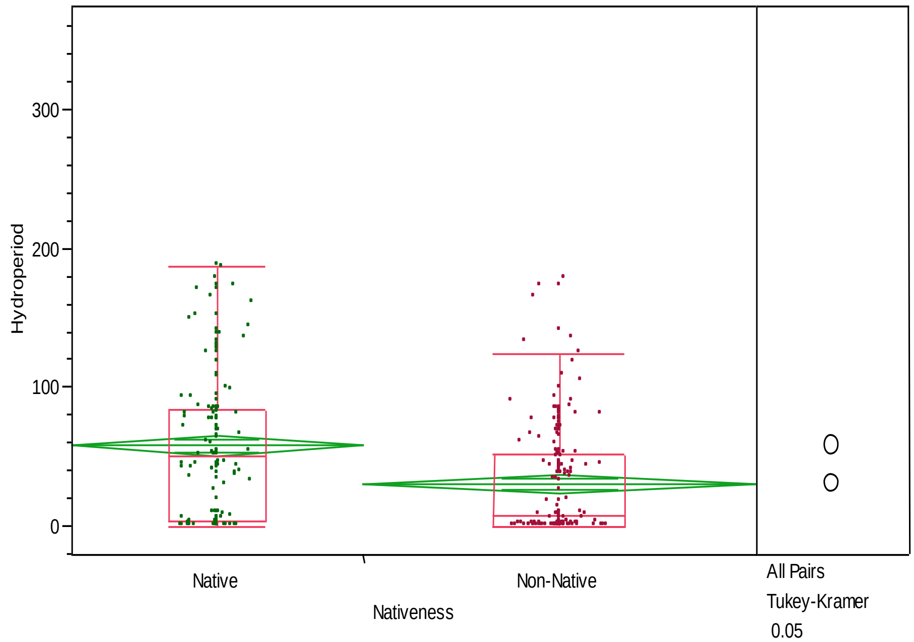


Figure 9. Hydroperiod and species nativeness for Larson East and West wetlands.

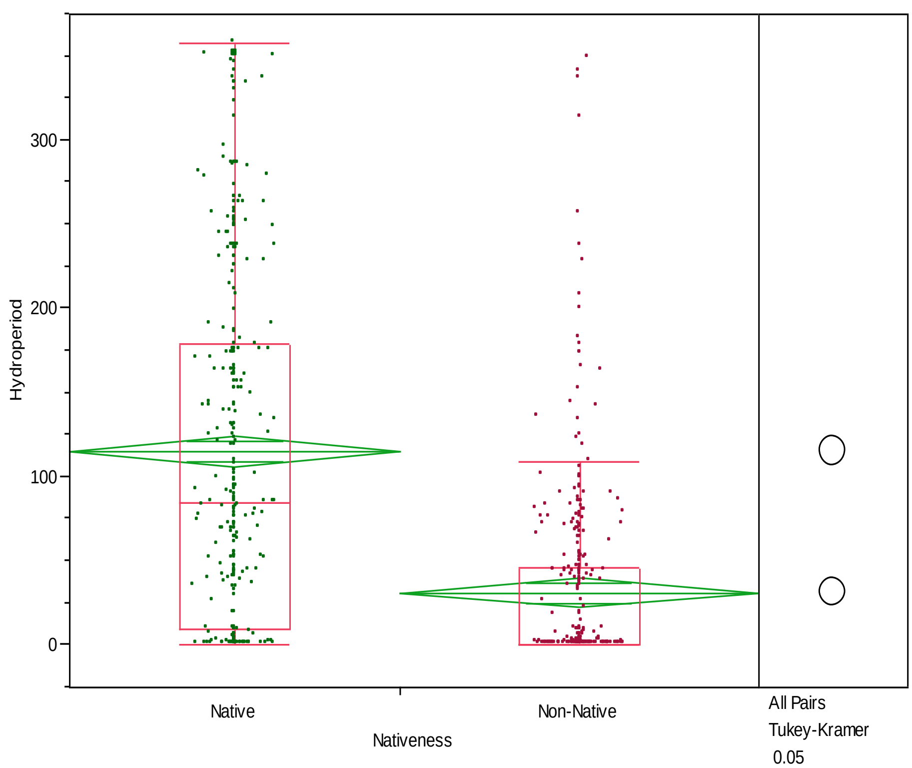


Figure 10. Combined hydroperiod and species nativeness for all wetlands.

To illustrate the shift in relative nativeness along the wetlands hydrologic gradient, a logistic fit of the percent dominance of native species relative to the interpolated hydroperiod at the sampling location was used (Figure 11)

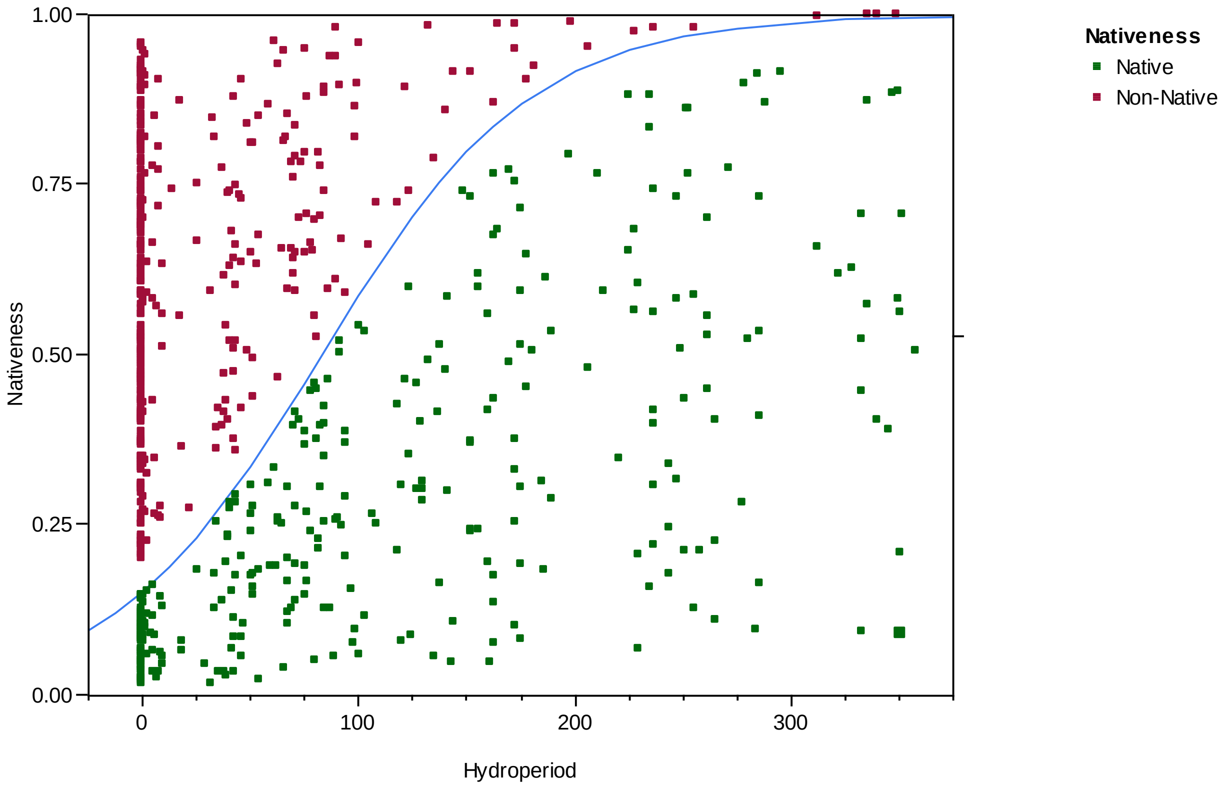
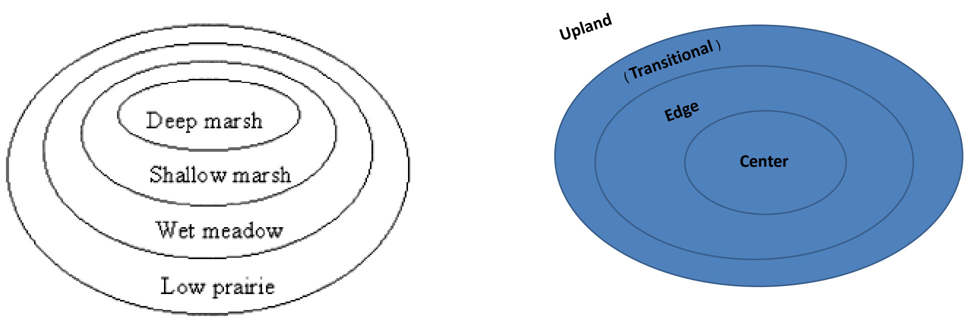


Figure 11. Logistic fit of nativeness. This figure graphically represents the percent coverage of the species nativeness as sampled along their respective site hydroperiods over the whole study for both sites.

. The data clearly indicate that there is a trend that Florida native species have a higher hydroperiod tolerance when compared to those non-native species found within improved pasture ranchlands. Species nativeness results support the hypothesis that vegetation nativeness (native vs. non-native) occurrence will be inversely related to hydroperiod.

This research also suggests that, Okeechobee isolated wetlands exhibit similar vegetation zonation as do other isolated wetlands along a hydrologic gradient as a result of subtle variations of graminoids and forbs species. In the Prairie Pothole region, Kirby et al. have described such zones (Low prairie, Wet meadow, Shallow marsh and Deep marsh) in their research as illustrated in Figure 12-a (1998). This research has found evidence to support similar zone classification. However, this research utilized the zone names of Upland, Edge and Center as they are less confusing to the layman/rancher for referencing the vegetation communities, their subsequent land management and potential protection. There may be evidence to support a fourth zone, often refered to as Transitional between the Upland and Edge zones, when the slope is very gradual between the wetland center (often a pelagic center with free floating plants) and adjacent upland (Figure 12-b). The vegetation within these zones can shift rather abruptly or so subtlety that it takes a trained eye to tease apart their appropriate boundaries.



A B

Figure 12. A) Kirby described 4 vegetative zone types in isolated wetlands of the Prairie Pothole Region (Kirby et al. 1989). B) Similar zones, although labeled differently were identified in this research.

CONCLUSIONS

When compiling the data needed to perform this baseline study, one must point out that in ecological/field studies it is rather difficult to control for all environmental conditions like storms, droughts, trampling, competition (space, light, nutrient, etc.), and natural and artificial herbivory. The antecedent rainfall conditions, and differences in annual (seeded) vs. perennial (rhizomes) species might also be effected and influencing these vegetation plant communities. Therefore, it would be ideal to have a minimum of three to five "normal" years of data for analysis and not just the two presented here. However, there is enough evidence to suggest that vegetation species are related to their respective hydroperiods as described for vegetative nativeness. Although there are limitations in the duration of this dataset, estimating the range in hydroperiod for each of the vegetative zones allows for some prediction of how vegetative communities might shift in response to changes in hydrologic condition.

Species nativeness was significantly related to hydroperiod and indicated a clear trend that Florida native species had higher hydroperiod tolerances unlike non-native species. Overall, the study has shown a strong influence of hydroperiod on vegetative community composition in isolated wetlands of improved pastures and provides at least a preliminary means of quantifying and documenting ecological services from the impacts of hydrologic restoration of isolated wetlands in this region.

Further Research & Applications

There is need for more investigation into the conflation between the hydrologic terms of hydroperiod (frequency and duration) and hydropattern (frequency, flow, duration, depth and seasonality/timing) for scientific research and environmental monitoring. Times past may have once favored the simple calculations of hydroperiod, but there is increased need to further develop the quantitative usefulness of the more complex hydropattern. Future application of this information could result in development of a cell-phone application that integrates plant information and the predicted hydroperiod for land managers. Flashcard decks of species information are already accessible to the technology savvy that has internet-ready phones for taking pictures and even taking rough GPS points of interest. The potential development of such an application would allow for rapid interpretation of hydroperiod based on determination of vegetative species and have further implications into pasture carrying capacity based on climatic or managed changes in pasture hydroperiod with such a programs as NE-PES.

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APPENDIX A
SUPPLEMENTAL RAINFALL DATA

Table A-1. Total annual rainfall measured from the "BASSETT_R" weather station operated by the South Florida Water Management District. The represented antecedent rainfall is representative of the rainfall directly involved 365-days prior to field sampling.

	2003	2004	2005	2006	2007	Antecedent Rainfall 2004	Antecedent Rainfall 2005
January	4.05	1.85	1.2	0.06	0.07	1.85	1.2
February	1.39	2.89	1.18	0.48	0.6	2.89	1.18
March	0.92	0.74	5.01	0.36	0.64	0.74	5.01
April	3.43	1.71	2.24	1.18	1.65	1.71	2.24
May	1.63	0.41	5.39	0.84	1.5	0.41	5.39
June	7.07	5.84	14.49	5.92	1.99	5.84	14.49
July	7	2.28	4.87	6.02	8.66	2.28	*2.28*
August	8.24	8.55	3.31	3.19	4.57	*8.24*	*8.55*
September	5.06	11.27	2.53	3.23	7.86	*5.06*	*11.27*
October	0.35	0.44	7.55	0.59	6.3	*0.35*	*0.44*
November	2.34	0.15	2.76	0.29	0.13	*2.34*	*0.15*
December	2.61	2.5	0.3	1.22	0.19	*2.61*	*2.5*
	44.09	38.63	50.83	23.38	34.16	34.32	54.7

The South Florida Water Management District, headquartered in West Palm Beach, Florida, maintains environmental and meteorological data for public records and scientific research. Most of this data is available online using their environmental database, DBHYDRO, found through their website at http://www.sfwmd.gov. The above data are summarized from the large dataset provided for the weather station known as "Bassett_R." It is located in Okeechobee County (map section 22, township 35, range 34 at 272441.143 latitude and 805516.211 longitude) in the S-191 priority basin.

APPENDIX B
SUPPLEMENTAL TRANSECT REALTIVE ELEVATIONS

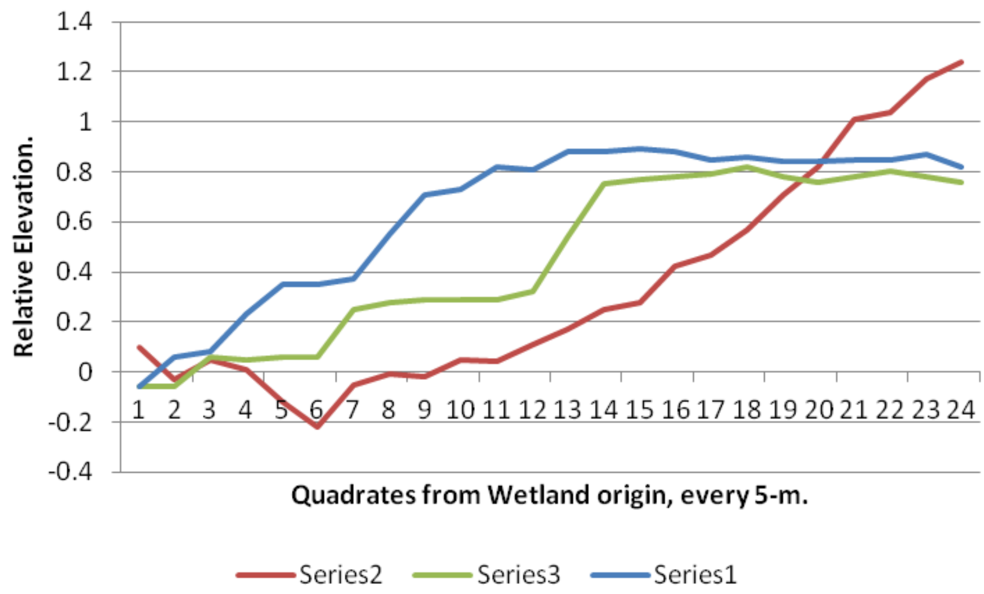

Figure B-1. Beaty North wetland relative elevations for transects (Series 2 is Transect 2).

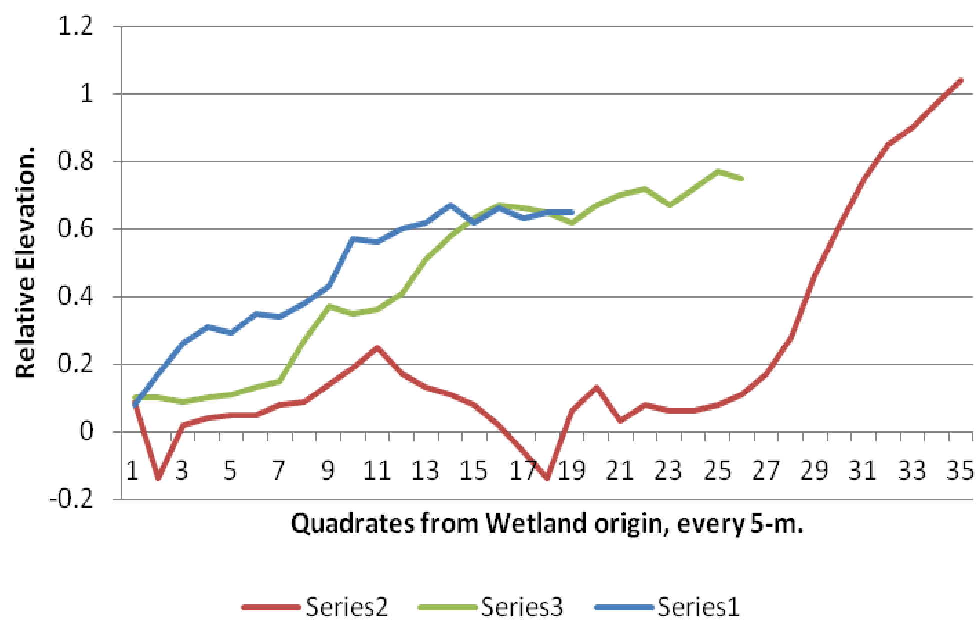

Figure B-2. Beaty North wetland relative elevations for transects (Series 3 is Transect 3).

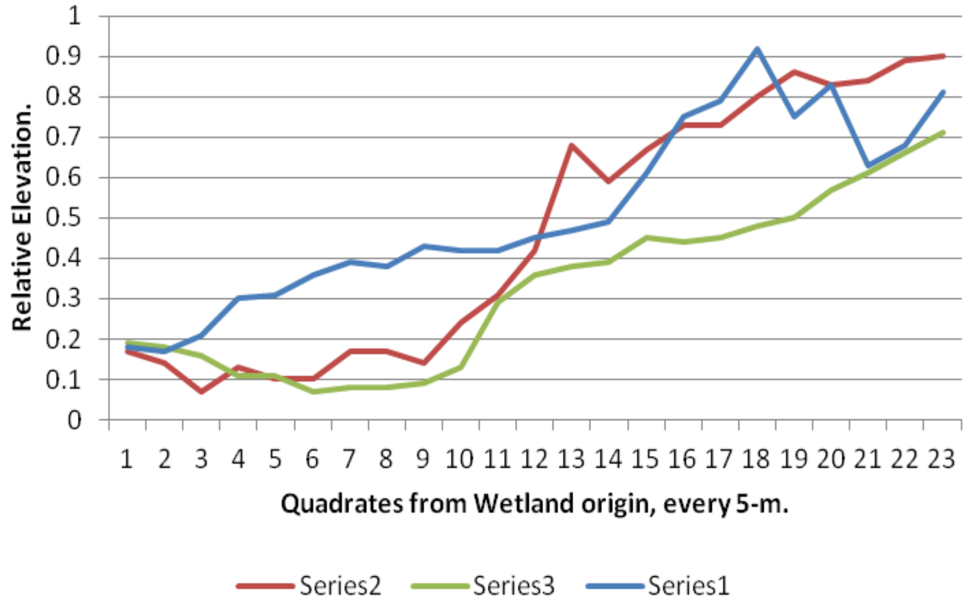

Figure B-3. Larson East wetland relative elevations for transects (Series 1 is Transect 1).

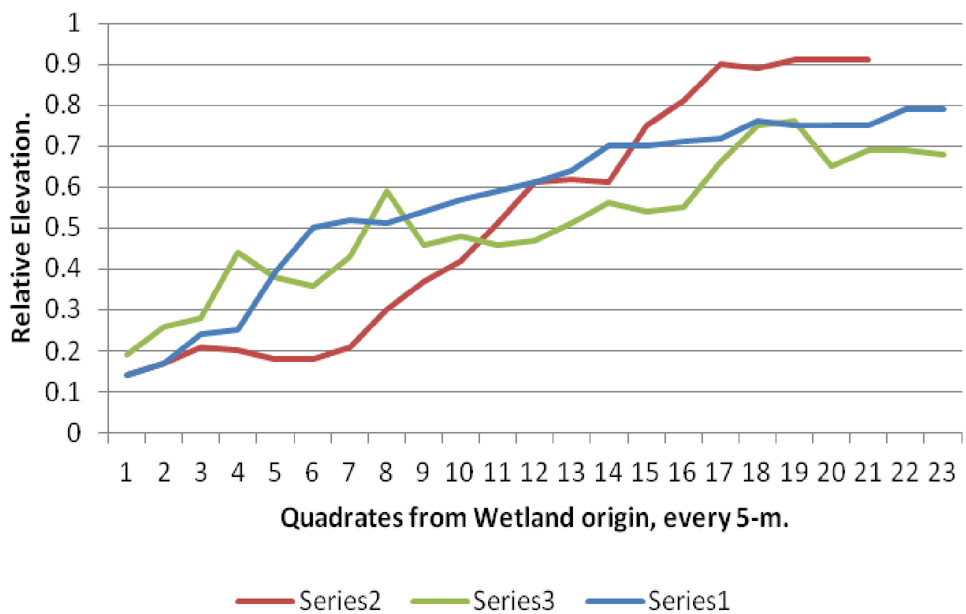

Figure B-4. Larson West wetland relative elevations for transects (Series 2 is Transect 2).

APPENDIX C
SUPPLEMENTAL HYDROGRAPHS OF SAMPLED WETLANDS

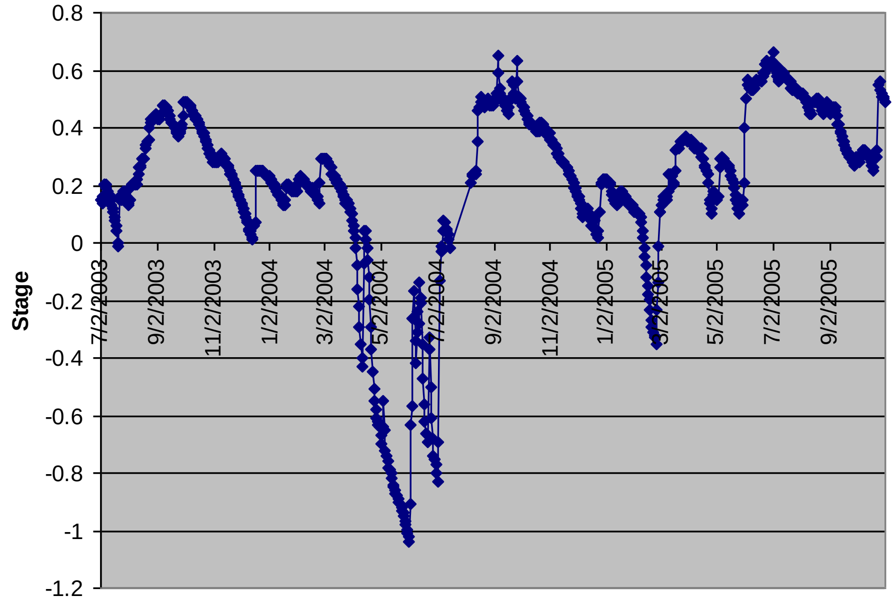

Figure C-1. Hydrograph of the Beaty North wetland. July 2003 – October 2005.

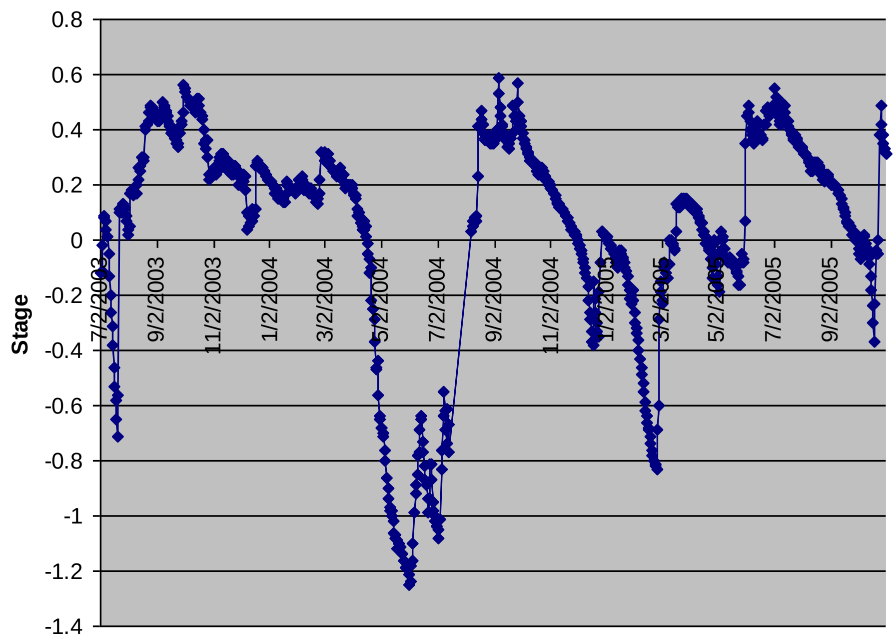

Figure C-2. Hydrograph of the Beaty South wetland. . July 2003 – October 2005.

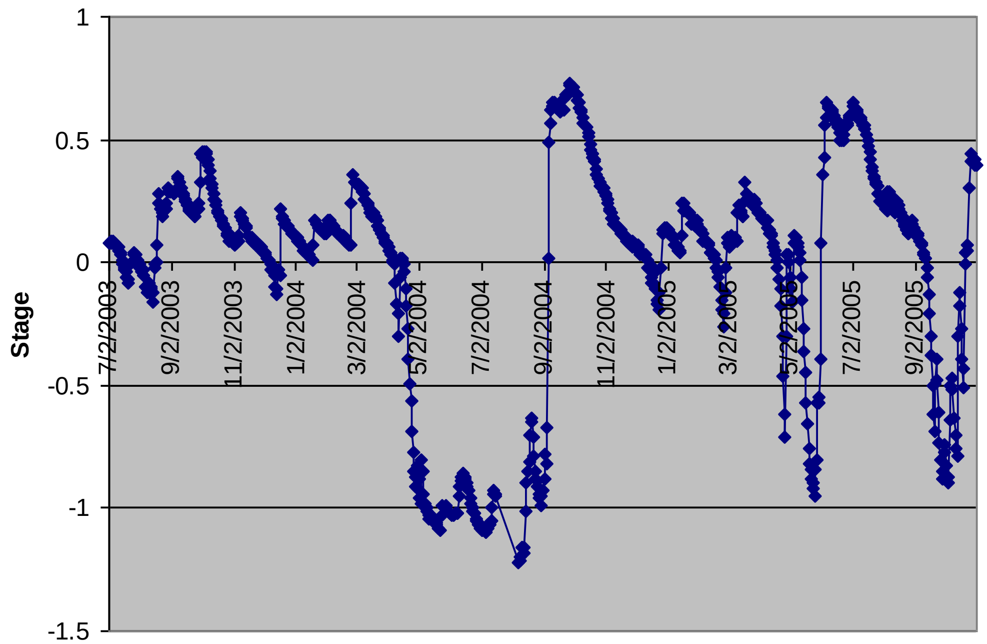

Figure C-3. Hydrograph of the Larson West wetland. . July 2003 – October 2005.

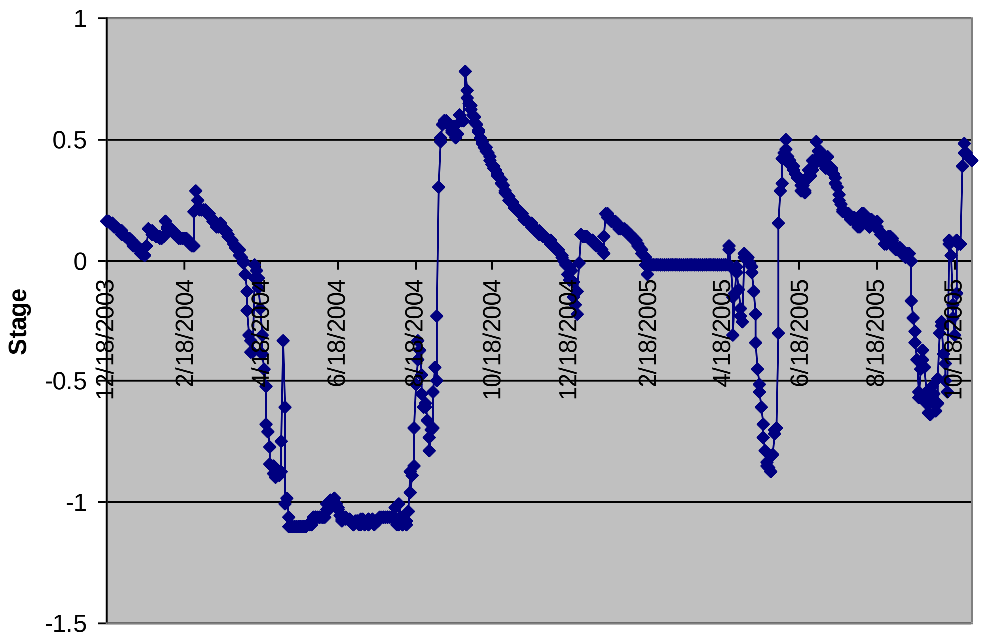

Figure C-4. Hydrograph of the Larson East wetland. . December 2003 – October 2005.

APPENDIX D
SUPPLEMENTAL COMMON SPECIES DATA

Table D-1. Most common species data in review.

Species	Nativeness	Hydroperiod 25%	Hydroperiod Median	Hydroperiod 75%
Andropogon glomeratus	Native	0	0	84
Alternanthera philoxeroides	Non-Native	52	76	85
Cynodon dactylon	Non-Native	0	0	17
Centella erecta	Native	0	6	52
Echinocloa crus-galli	Non-Native	54	78	95
Eleocharis equisetoides	Native	0	0	179
Hymenachne amplexicaulis	Non-Native	54	86	136
Hemarthria altissima	Non-Native	0	52	92
Juncus effusus	Native	54	129	222
Lindernia grandiflora	Native	9	40	313
Ludwigia repens	Native	51	77	122
Luziola fluitans	Native	52	77	167
Paspalum notatum	Non-Native	0	0	16
Pontederia cordata	Native	140	188	285
Panicum hemitomon	Native	120	190	256
Phyla nodiflora	Native	0	5	40
Polygonum hydropiperiodes	Native	82	158	237
Sagittaria lancifolia	Native	89	125	199

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