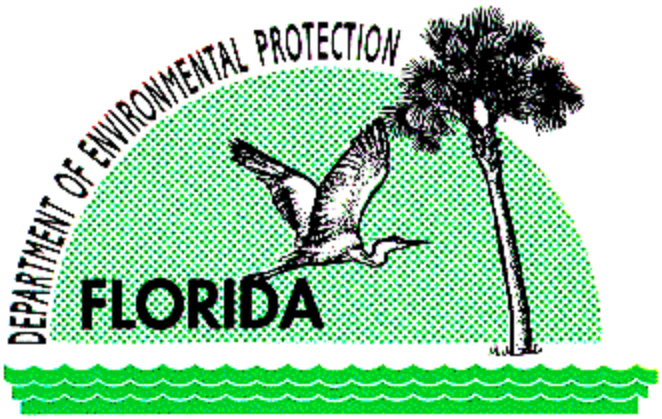


An Investigation of Canals in Southwest Florida: Relationships Between Biological Health, Water Quality, and Habitat

Lee and Collier Counties

June 2001

Bureau of Laboratories

Division of Resource Assessment & Management

Comprehensive Quality Assurance Plan No's:

Laboratories- 870346G & 870688G

Field- 980028

Executive Summary

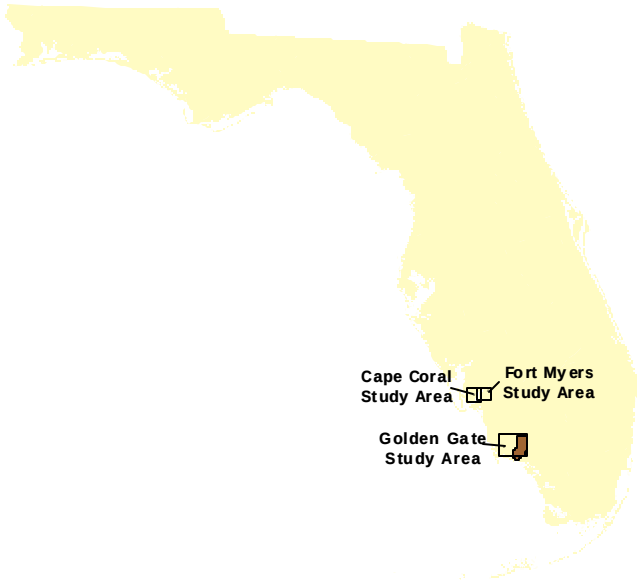
In the fall of 1999 and the spring of 2000, the FDEP collected habitat assessment, invertebrate dip net sweep, physical/chemical measurement, and water chemistry data at 18 canal sites in southwest Florida. The goal of this study was to further establish biological expectations for canal systems in the southwest Florida region, and to relate the canals' biological condition to habitat and water quality variables.

A priori evaluations of water quality and habitat categories for the canals met with mixed results. Cluster analysis demonstrated that the "test" vs. "reference" evaluations were valid for water quality nutrients (TKN, TP, ammonia, nitrate-nitrite, AGP), but not for habitat. However, no correlation between the water quality data and the SCI scores could be determined. Furthermore, comparisons of habitat reference vs. habitat test sites and SCI results from those sites showed no relationship. A relationship was observed between the SCI and habitat assessment scores between sampling events. Changes in the SCI scores followed changes in habitat assessment scores between the September/October 1999 event and the March 2000 event. Overall, habitat assessment total scores ranged from poor to low sub-optimal in all canal sites in 1999. Based on their artificial construction, canals can not be expected to span the full range of scores found in the stream habitat assessment procedures, even in expected "reference canal" habitat conditions.

Stream Condition Index (SCI) type of sampling, utilizing 20 dipnet sweeps, is currently the best available sampling tool to characterize the biological health of canal systems. Our study confirmed that 20 dipnet sweeps effectively collected approximately 70% of the available taxa in canals, with only rare taxa being added when more than 20 sweeps were collected. Furthermore, 20 sweeps could clearly distinguish high taxa richness canals (*e.g.*, Syracuse) from those with lower diversity of organisms (*e.g.*, Winkler). However, our *a prioi* approach to classifying least disturbed canals (which are all artificially created systems) was not successful. Until additional 20 dipnet sweep data is collected from an assortment of canals subject to varying degrees of human disturbance (habitat removal, water quality problems), we can not fully establish reasonable expectations for these artificial systems. Additional data would help determine which biological metrics are best suited for distinguishing between "good" and "stressed" canals. If additional canals sampling is done (sufficient to bring the total number of sites up to approximately 50) it is possible that a Canal Condition Index (CCI) could be formulated for future use. This CCI would need to consider supplementary factors, such as eco-region and flow conditions (flowing vs. stagnant) during the calibration process.

It was encouraging that many of the canals in this study actually passed the Peninsular thresholds of the SCI, indicating the resilience of the biological communities inhabiting them. However, we were not able to correlate the SCI with either water quality or visual habitat measurements, suggesting that other unobserved factors are influencing the invertebrate health of these systems.

Figure 1: Overview Map of Study Areas



Introduction

For nearly 10 years, The Florida Department of Environmental Protection (FDEP) has used the Stream Condition Index (SCI) sampling methodology for determining the health of biological communities in Florida streams. The SCI compares multiple parameters at a site to thresholds established from "reference" conditions calibrated to specific geographic areas. This approach has worked well in streams and rivers across the nation. More recently, the SCI has been used to assess the health of South Florida canal systems. A 1998 study by Tetra Tech demonstrated the SCI could be used to evaluate biological health in the canal systems of Southeast Florida.

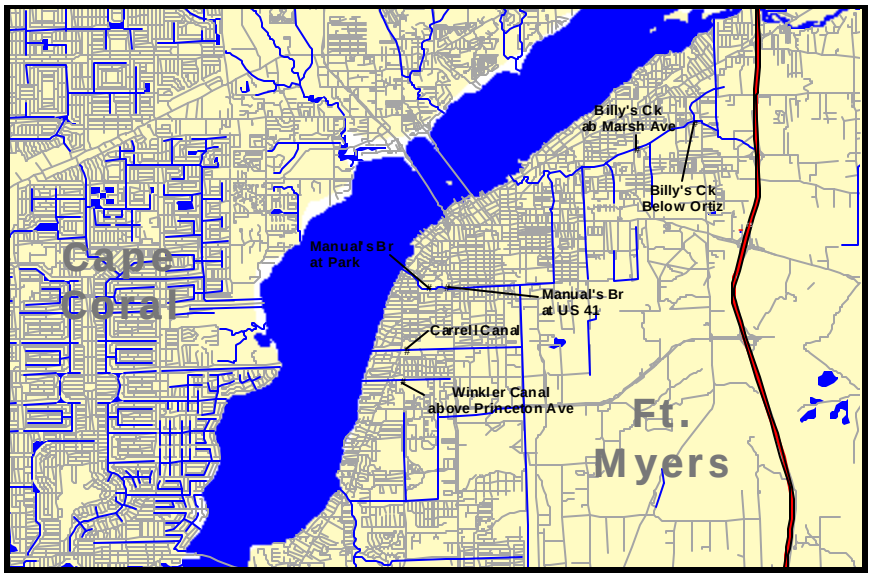


Figure 2: Ft. Myers Study Area

The goal of this study was to further establish biological expectations for canal systems in the southwest Florida region, and to relate the canals' biological condition to habitat and water quality variables.. The FDEP collected habitat assessment, invertebrate dip net sweep, physical/chemical measurement and water chemistry data at 18 sites in southwest Florida to determine differences in the canal systems. Sites were categorized prior to sampling as either water quality reference (areas of low NPS, non -point source, pollution) or test (areas most likely impacted by NPS pollution) based on local land use. Habitat reference (productive instream

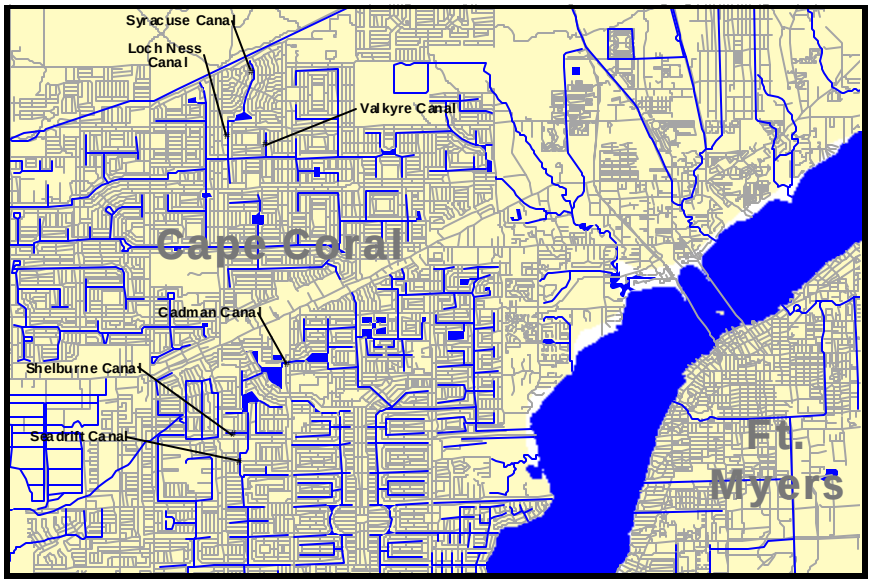


Figure 3: Cape Coral Study Area

habitat) or test (little or unproductive instream habitat, *i.e.* seawalls) classifications were based on the presence or absence of artificial structures and frequency of management activities such as herbicide application and dredging.

Seven large, box-cut canals in Cape Coral, FL were categorized as NPS unimpacted (habitat and water quality reference sites) or impacted (habitat and water quality test sites), mainly according to degree of residential development. The seven sites were Syracuse Canal, Loch Ness Canal, Valkyrie Canal (all three water quality and habitat reference), Seadrift Canal, Shelbourne Canal (both water quality and habitat test) and Cadman Canal at two sites (both sites were water quality test, one was habitat reference and the other habitat test). The Ft Myers sites were shallower, faster flowing canals located in more urban settings (mainly water quality test). Two canals (one water quality test, Manuals Branch, and the other water quality reference, Billy's Creek) were sampled at distinctly separate reaches to determine differences in invertebrate communities in systems with similar water quality. Manuals Branch at US 41 and Billy's Creek below Ortiz contained "good" habitat (reference sites). On the other hand, Manuals Branch at Park and Billy's Creek above Marsh Avenue had little or stressed habitat (test sites). Five more sites were sampled in the Golden Gate Community for determination of baseline conditions before hydrologic modifications are made (Prairie Canal, Merritt Canal, Faka Union Canal and two wetland sites; Fakatchee Prairie and Remnant Slough in Picayune).

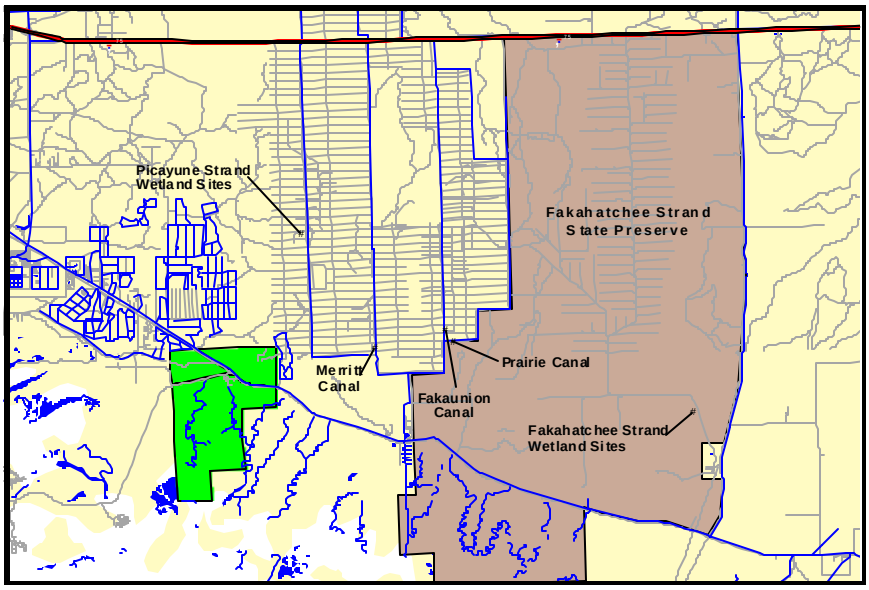


Figure 4: Golden Gate Study Area

Methods

Habitat quality (FDEP 1996, Biology Section Standard Operating Procedure #IZ-21) was determined for each station based on eight attributes known to have effects on the stream biota. Each parameter is scored on a scale of 1 to 20 points with 20 points being "optimal". Substrate diversity, substrate availability, water velocity and habitat smothering comprise the "primary habitat components". The "secondary habitat components" are artificial channelization, bank stability, riparian buffer zone width and riparian zone vegetation quality. Based on the sum of these individual scores, the overall habitat quality is assigned to one of four categories: Optimal (121-160 points); Sub-optimal (81-120 points); Marginal (41-80 points); and Poor (0-40 points).

Benthic macroinvertebrate communities were evaluated using the Stream Condition Index (SCI) sampling methodology (FDEP 1996, Biology Section Standard Operating Procedure #IZ-30). The SCI is a composite macroinvertebrate metric (Barbour *et al.* 1996). The SCI assigns points to a variety of parameters, depending on how closely each parameter approaches an expected reference condition. These thresholds vary slightly with geographic region and sampling season. Invertebrates were collected from the most productive habitats (*e.g.*, snags, leaf packs, root mats, vegetation, rock/rubble) at

each site using 20 discrete D-frame dip net sweeps. In 1999, three canal sites were over-sampled using the same technique to test the calibration of SCI sampling procedures to canal conditions. Eight sets of five sweeps each (a total of 40 dip net sweeps) were taken to develop species accumulation curves. The samples were preserved with formalin in the field and brought back to the FDEP Central Laboratory for identification. Thresholds, specific to this method, have been established for total taxa, EPT Index, percent dominant taxon, Florida Index, percent Diptera, total number of Chironomidae, and percent filter-feeders.

Explanation of Measurements of Community Health

Selected measurements of macroinvertebrate community health were employed to assess a site. These are briefly discussed here.

Taxa richness: Stress tends to reduce the number of different types of organisms present in a system, although moderate nutrient enrichment may sometimes be correlated with increased algal taxa richness.

Numbers of pollution sensitive taxa: Some organisms become rare or absent as the intensity or duration of disturbance increases. For example, the Florida Index assigns points to stream-dwelling macroivertebrates based on their sensitivty to pollution (see Ross 1990). A site with a high Florida Index score is considered healthy.

Ephemeroptera/Plecoptera/ Trichoptera (EPT) Index: This index is the sum of the number of larval EPT taxa present. Higher EPT values are associated with healthier systems.

Community structure: Substantial shifts in the proportions of major groups of organisms, compared to reference conditions, may indicate degradation. In marine systems, an increase in the percent tubificid oligochaetes, a decrease in the percent pelecypods, and a decrease in the number of polychaete taxa are all considered indicators of disturbance (Engel *et al.* 1994).

Trophic composition/feeding guilds: Disturbances can shift the feeding strategies of invertebrates. In Florida, for example, pollution may be responsible for reducing the numbers of filter-feeders (FDEP 1994) and shredders (EA Engineering 1994).

Water samples from all sites were analyzed for ammonia, nitrate/nitrite, total Kjeldahl nitrogen (TKN), total phosphorus (TP), and algal growth potential (AGP) at the FDEP Central Laboratories in Tallahassee. Sampling was performed by FDEP Bureau of Laboratories staff with help from personnel from FDEP SW District, Fakahatchee Strand State Preserve, City of Cape Coral and City of Ft. Myers.

Results and Discussion

Canals: 1999: Water Quality Reference Sites vs. Water Quality Test Sites:

Based on visual observations during a reconnaissance trip, the water quality reference canals established for this study were: Billy Ortiz, Lochness, Syracuse, Valkyrie, Billy Marsh, Fakaunion, Merritt, and Prairie. Duplicate samples were taken at Billy Ortiz and Lochness. The water quality test canals established for this study were: Cadman/Restored side, Manual US 41, Cadman/Seawall side, Carrell, Manual Park, Seadrift, Shelburne, and Winkler. The results of the September/October 1999 sampling were unexpected, since nutrient concentrations and algal growth potential measurements (AGP) tended to be higher at water quality reference sites than at water quality test sites. Ammonia concentration ranged from 0.014 to 0.98 mg/L at the water quality reference sites and from 0.012 to 0.22 mg/L at the water quality test sites. Nitrate-nitrite concentration ranged from below limits of detection (BLD) to 0.31 mg/ L at reference sites and from 0.01 to 0.18 mg/L at test sites. Total Kjeldahl nitrogen (TKN) concentration in the water ranged from 0.32 to 1.9 mg/L at reference sites and from 0.51 to 1.0 mg/L at test sites. Total phosphorous concentrations ranged from below limits of detection (BLD) to 0.31 mg/

L at reference sites and from 0.015 to 0.15 mg/L at test sites. (See data tables) Algal growth potential concentrations ranged from 0.1 to 43.9 mg dry wt/L at the water quality reference sites and from 0.1 to 9.3 mg dry wt/L at the water quality test sites. Stream condition index (SCI) scores ranged from 19 to 29 at the water quality reference sites and from 21 to 29 at the water quality test sites.

Canals: 1999: Habitat Reference Sites vs. Habitat Test Sites:

The habitat reference canals established for this study were: Billy Ortiz, Lochness, Syracuse, Valkyrie, Cadman/ Restored side, and Manual US 41. Duplicate samples were taken at Billy Ortiz and Lochness. The water quality test canals established for this study were: Billy Marsh, Fakaunion, Merritt, Prairie, Cadman/ Seawall side, Carrell, Manual Park, Seadrift, Shelburne, and Winkler. For the September/October 1999 sampling, SCI scores and habitat assessment total scores had wider ranges at the habitat test sites than at the habitat reference sites, with values for the reference sites falling within the test site ranges. Stream condition index (SCI) scores ranged from 21 to 25 ("good" category) at the habitat reference sites and from 19 to 29 ("poor" to "excellent" categories) at the habitat test sites. Habitat assessment total scores ranged from 65 to 89 ("marginal" to "sub-optimal" categories) at habitat reference sites and from 56 to 114 (also "marginal" to "sub-optimal" categories) at test sites.

Canals: 1999 ("Summer/Wet") vs. 2000 ("Winter/Dry"):

The canals that were resampled in March 2000 to examine seasonal changes were: Billy's Creek at Ortiz, Lochness, Syracuse, Manual US 41, Shelburne, and Winkler Canals. Samples at Billy's Creek at Ortiz and Lochness were again duplicated. Billy Ortiz, Lochness, and Syracuse were established as water quality reference and habitat reference canals for this study. Manual at US 41 was a water quality test and habitat reference canal; Shelburne and Winkler were water quality test and habitat test canals. From the 1999 sampling to the 2000 sampling, ammonia concentration decreased at all three of the water quality reference sites that were retested, including duplicates. Ammonia concentration decreased at Shelburne, but increased at the other two water quality test sites. Nitrate-nitrite concentration decreased at all six of the resampled sites between

Figure 5

Macroinvertebrate Parameters	**September/October 1999 Sampling**							
Station	BILLYMARSH	BILLYORTIZ	CADMANRSTR	CADMANSEWL	CARRELL	FAKAUNION	LOCHNESS	MANUALPARK
SCI	19	25	21	21	21	29	23	23
Peninsula Evaluation	poor	good	good	good	good	excellent	good	good
Number of Taxa	21	27	26	30	31	38	35	24
EPT Index	3	3	3	1	1	4	2	2
% Contribution Dominant Taxa	21.43	15.45	15.22	25.68	19.85	15.86	21.14	28.69
Florida Index	5	10	6	3	1	10	2	8
% Diptera	3.06	39.09	45.65	40.88	35.88	46.9	53.14	32.79
Total Number Chironomidae	1	5	8	10	9	12	14	9
% Filterer-Feeders	1.02	7.27	7.61	3.04	3.44	3.45	10.57	1.64
Physical-Chemical Data								
Station	BILLYMARSH	BILLYORTIZ	CADMANRSTR	CADMANSEWL	CARRELL	FAKAUNION	LOCHNESS	MANUALPARK
Habitat Assessment- Total	56	89	65	65	61	109	65	114
Substrate Diversity	6	16	8	8	5	13	7	16
Substrate Availability	11	20	5	5	12	7	9	13
Velocity	11	18	3	3	10	18	2	18
Smothering	11	11	20	20	17	16	20	15
Primary Score	39	65	36	36	44	54	38	62
Dissolved Oxygen (mg/L)	3.7	4.2	8.6	8	3.5	3.4	4.5	6.4
Nutrient data								
Station	BILLYMARSH	BILLYORTIZ	CADMANRSTR	CADMANSEWL	CARRELL	FAKAUNION	LOCHNESS	MANUALPARK
Ammonia (mg/L)	0.064	0.97	0.22	0.22	0.096	0.096	0.023	0.022
Nitrate-Nitrite (mg/L)		0.31	0.03	0.02	0.15	0.15	0.01	0.18
TKN (mg/L)	1.2	1.85	1	1	0.95	0.95	0.535	0.67
Total Phosphorus (mg/L)	0.31	0.23	0.021	0.015	0.11	0.11	0.015 BDL	0.15
AGP (mg dry wt/L)	43.9	38.7	0.3	1.1	3.9	3.9	0.25	9.3

Figure 6

Macroinvertebrate Parameters	**September/October 1999 Sampling**							
Station	MANUALUS41	MERRITT	PRAIRIE	SEADRIFT	SHELBURNE	SYRACUSE	VALKYRIE	WINKLER
SCI	21	23	19	29	21	25	23	21
Peninsula Evaluation	good	good	poor	excellent	good	good	good	good
Number of Taxa	25	32	19	40	30	48	24	28
EPT Index	2	3	3	4	0	3	4	1
% Contribution Dominant Taxa	22.03	59.56	40.63	23.14	22.22	26.8	14.29	19.67
Florida Index	4	6	5	6	2	5	8	1
% Diptera	7.63	26.22	37.5	44.1	47.22	36	60.2	19.67
Total Number Chironomidae	3	11	6	13	11	16	7	8
% Filterer-Feeders	22.03	1.33	1.04	13.1	3.24	6.2	10.2	0
Physical-Chemical Data								
Station	MANUALUS41	MERRITT	PRAIRIE	SEADRIFT	SHELBURNE	SYRACUSE	VALKYRIE	WINKLER
Habitat Assessment- Total	65	99	98	57	60	67	82	74
Substrate Diversity	6	12	12	3	4	8	8	11
Substrate Availability	12	5	4	8	6	10	20	20
Velocity	16	15	15	3	1	2	1	5
Smothering	13	18	13	20	20	20	20	17
Primary Score	47	50	44	34	31	40	49	53
Dissolved Oxygen (mg/L)	7.3	3	1.6	7.8	6.5	3.3	6.3	1.6
Nutrient data								
Station	MANUALUS41	MERRITT	PRAIRIE	SEADRIFT	SHELBURNE	SYRACUSE	VALKYRIE	WINKLER
Ammonia (mg/L)	0.043	0.068	0.038	0.012	0.025	0.021	0.014	0.033
Nitrate-Nitrite (mg/L)	0.14	0.02	0.01	0.01	0.02	0.02	0 BDL	0.09
TKN (mg/L)	0.65	0.67	0.41	0.96	0.82	0.62	0.32	0.51
Total Phosphorus (mg/L)	0.12	0.015 BDL	0.015	0.053	0.018	0.019	0.018	0.062
AGP (mg dry wt/L)	5.9	0.2	0.3	0.1	0.3	0.5	0.1	0.2

September/October 1999 and March 2000 (Figure 8). Total Kjeldahl nitrogen (TKN) concentration in the water decreased at all three water quality reference sites (Figure 9). TKN concentration increased at one, decreased at one, and remained unchanged at one of the water quality test sites. Total phosphorous (TP) concentration increased at two of the three water quality reference sites; it remained unchanged at Lochness (Figure 10). TP concentration decreased at two of the three water quality test sites, but increased at Manual US 41. Algal growth potential (AGP) concentration decreased at all six of the resampled sites.

From September/October 1999 to March 2000, habitat assessment scores resulted in a change of category at only one site, Billy's Creek at Ortiz, which had a decrease from 89 ("suboptimal") to 69 ("marginal"). Winkler Canal had the largest change, a 33-point drop from 1999 to 2000 (74 to 41). However, the site was in the "marginal" category for both evaluations. Syracuse and Lochness Canals received higher scores in March 2000 (greater than 10 points) but this did not result in a change of category.

From September/October 1999 to March 2000, the SCI scores at Billy's Creek at Ortiz decreased dramatically from 25, "good" to 9, "severely degraded. Duplicate samples taken during both periods confirmed the decrease (25 in 1999 and 11 in 2000). The SCI at Winkler Canal also fell from a score of 21 points ("good") in September/ October 1999 to 17 points ("poor")

Figure 7

Macroinvertebrate Parameters	**March 2000 Sampling**					
Station	BILLYORTIZ	LOCHNESS	MANUALUS41	SHELBURNE	SYRACUSE	WINKLER
SCI	9	27	21	25	27	17
Peninsula Evaluation	severely degraded	excellent	good	good	excellent	poor
Number of Taxa	10	40	26	32	45	23
EPT Index	0	6	2	4	6	2
% Contribution Dominant Taxa	72.16	14.88	13.48	11.71	32.31	32.29
Florida Index	1	8	3	5	8	1
% Diptera	1.03	38.02	24.72	27.93	32.82	17.71
Total Number Chironomidae	1	14	10	5	17	6
% Filterer-Feeders	3.61	6.61	5.06	3.15	10.51	4.17
Physical-Chemical Data						
Station	BILLYORTIZ	LOCHNESS	MANUALUS41	SHELBURNE	SYRACUSE	WINKLER
Habitat Assessment- Total	69	78	73	59	79	41
Substrate Diversity	13	10	12	8	10	3
Substrate Availability	14	20	14	8	11	20
Velocity	9	2	2	1	6	3
Smothering	12	20	17	17	19	6
Primary Score	48	52	47	34	46	32
Dissolved Oxygen (mg/L)	9.1	10.9	6.3	8.7	7.3	10.3
Nutrient data						
Station	BILLYORTIZ	LOCHNESS	MANUALUS41	SHELBURNE	SYRACUSE	WINKLER
Ammonia (mg/L)	0.0645	0.01	0.066	0.013	0.01 BDL	0.046
Nitrate-Nitrite (mg/L)	0.02	0	0.03	0 BDL	0 BDL	0.04
TKN (mg/L)	1.3	0.4	0.74	0.63	0.41	0.51
Total Phosphorus (mg/L)	0.525	0.015	0.14	0.015 BDL	0.023	0.028
AGP (mg dry wt/L)	4.9	0.1	3.7	0.1	0.1	0.1

Figure 8: Nitrate-Nitrite

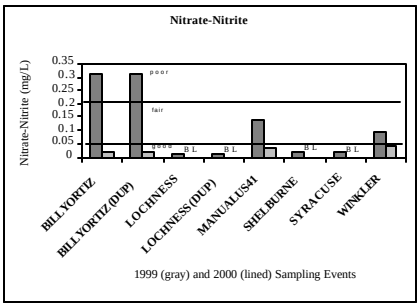


Figure 9: Total Kjeldahl Nitrogen

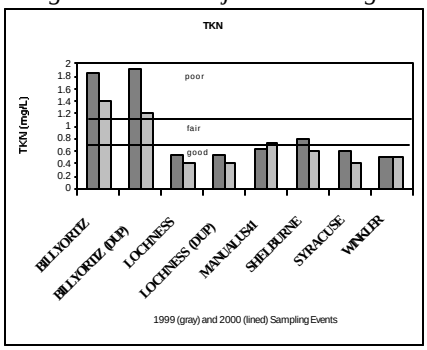


Figure 10: Total Phosphorus

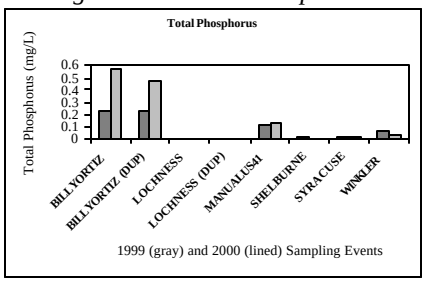
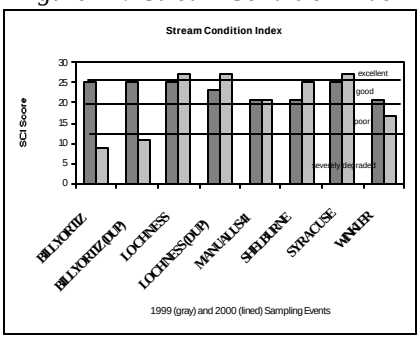


Figure 11: Stream Condition Index



in March 2000. Similarly, Billy's Creek at Ortiz and Winkler Canal decreased by more than 20 points on the habitat assessment evaluations. Lochness (23 to 27), Shelburne (21 to 25) and Syracuse Canals (25 to 27) increased slightly from the fall sampling to the spring event. Manuals Branch at US 41 remained unchanged (21 points, "good"). SCI scores mimicked changes in the habitat assessment scores at four of the six sites. Billy's Creek at Ortiz and Winkler Canal had lower evaluations and scores for the SCI and lower habitat assessment results, while Lochness and Syracuse Canals increased in both evaluations. Manuals Branch at US 41 and Shelburne Canal remained nearly unchanged in habitat assessment scores (less than 8 points difference) and changed very little in the SCI score (0 points for Manuals Branch and 4 points for Shelburne) and not at all for the SCI category ("good" for both sites during both sampling events).

Wetlands: 1999:

Two wetlands locations were sampled in September/October 1999, with three replicate macroinvertebrate (SCI) stations, three replicate macrophyte transects and one water chemistry station at each site. The wetland reference site was Fakahatchee Wet Prairie, and the wetland test site was Picayune Remnant Slough. The ammonia concentration was 0.035 mg/L at the wetland reference site and 0.014 mg/L at the wetland test site. Nitrate-nitrite concentration was 0.01 mg/L at the wetland reference site and below limits of detection (BLD) at the wetland test site. Total Kjeldahl nitrogen (TKN) concentration was 0.78 mg/L at the wetland reference site and 1.3 mg/L at the wetland test site. The total phosphorous concentration was 0.061 mg/L at the wetland reference site and 0.041 at the wetland test site. Algal growth potential (AGP) concentration was 0.4 mg dry wt/L

Figure 12

Wetland Reference Stations:

Macroinvertebrate Parameters			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
STORET	CANALS020	CANALS022	CANALS021
SCI	17	15	23
Peninsula Evaluation	poor	poor	good
Number of Taxa	26	20	29
Number of Ephemeroptera	2	0	2
Number of Plecoptera	0	0	0
Number of Trichoptera	0	1	1
EPT Index	2	1	3
% Contribution Dominant Taxa	12.63	46.25	12.09
Florida Index	1	3	2
% Diptera	16.84	11.25	32.97
Total Number Chironomidae	4	5	6
% Filter-Feeders	6.32	4.38	14.84
Physical-Chemical Data			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
Avg. Sample Depth (m)		0.3	
Specific Conductivity (umho/cm)		542	
Dissolved Oxygen (mg/L)		2.4	
pH (SU)		6.8	
Temperature (deg. C)		29.6	
Turbidity (NTU)		4.2	
Nutrient data			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
Ammonia (mg/L)		0.035	
Nitrate-Nitrite (mg/L)		0.01	
TKN (mg/L)		0.78	
Total Phosphorus (mg/L)		0.061	
AGP (mg dry wt/L)		0.4	

Figure 13

Wetland Test Stations:			
Macroinvertebrate Parameters			
Station	PICRMNTA	PICRMNTB	PICRMNTC
STORET	CANALS018	CANALS017	CANALS019
SCI	19	23	17
Peninsula Evaluation	poor	good	poor
Number of Taxa	28	28	24
Number of Ephemeroptera	1	1	1
Number of Plecoptera	0	0	0
Number of Trichoptera	0	1	0
EPT Index	1	2	1
% Contribution Dominant Taxa	22.88	22.02	32.71
Florida Index	1	4	1
% Diptera	53.39	43.12	40.19
Total Number Chironomidae	10	9	10
% Filter-Feeders	2.12	0	0.93
Physical-Chemical Data			
Station	PICRMNTA	PICRMNTB	PICRMNTC
Avg. Sample Depth (m)		0.1	
Specific Conductivity (umho/cm)		90	
Dissolved Oxygen (mg/L)		2.1	
pH (SU)		4.7	
Temperature (deg. C)		26.4	
Turbidity (NTU)		1.4	
Nutrient data			
Station	PICRMNTA	PICRMNTB	PICRMNTC
Ammonia (mg/L)		0.014	
Nitrate-Nitrite (mg/L)		0 BDL	
TKN (mg/L)		1.3	
Total Phosphorus (mg/L)		0.041	
AGP (mg dry wt/L)		0.4	

at both the wetland reference site and the wetland test site. Stream condition index (SCI) scores for the three replicates at the wetland reference site were 17 (poor), 15 (poor) and 23 (good). These scores average to an SCI score in the "poor" range. The wetland test site received scores of 19 (poor), 23 (good) and 17 (poor) for the SCI, which averaged slightly higher than the reference site. Note that wetlands benthic invertebrate criteria have not been established, and that these SCI scores are used only for comparison between the two systems. The wetlands plant transect data from the 2000 sampling event can be found in Appendices C-F.

Statistical Analysis

Calibration of the Dipnet Sampling Method in Canals:

The D-frame dip net sweep method (SCI) of sampling macroinvertebrates has been used for many years in Florida streams and, more recently in South Florida, in canals. However, canal systems do not operate the same way as natural streams; therefore, it was necessary to determine how many D-frame dip net sweeps were needed to get a representative sample of the organisms found in a canal.

In a stream, 20 D-frame dip net sweeps are collected from the most productive habitats and analyzed as one sample. For the canal calibration project, each of three canal stations was sampled with 40 dip net sweeps. In order to see how many new taxa occurred with additional sampling effort, the 40 sweeps were collected in eight sets of five sweeps each. All productive habitats were included in each set of five sweeps.

The collected organisms were identified and counted (Appendices G-I). The cumulative number of taxa and percent taxa by sweep set are presented in Figures 14 and 15, respectively. Figure 16 displays the percent of new taxa for each additional set of five sweeps processed. A randomized taxa accumulation curve (Figure 17) was computed using EstimateS software (Colwell, R.K. 1997; Version 5. Users' Guide and application published at: http://viceroy.eeb.uconn.edu/estimates.). Fifty randomizations were done for each five sweep set size.

The cumulative percent of taxa converges at approximately 70% for all three sites after four sets of five sweeps (Figure 15); however, the number of taxa and taxa accumulation curve are still increasing after that point. This is because there were many rare species, i.e., those with only one or two individuals in all 40 sweeps. Figure 17 shows a taxa gain of approximately 10% for each five sweep set after four sets of five sweeps.

Figure 14

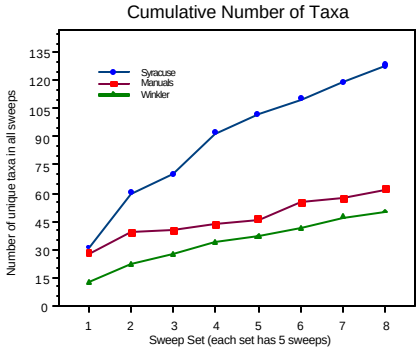


Figure 15

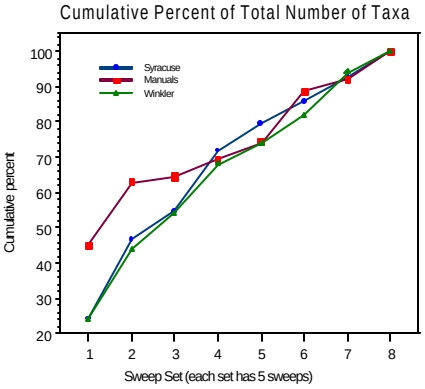
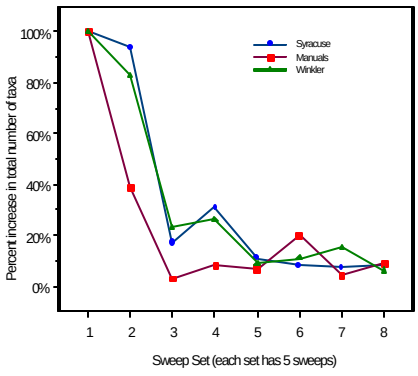


Figure 16



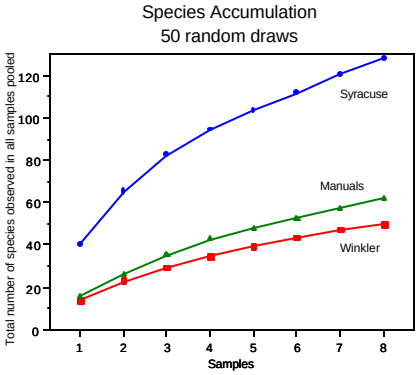
Since it is neither ecologically necessary nor cost-effective to enumerate every rare species found, the best sampling strategy for canals is to use 20 D-frame dipnet sweeps, which is the standard protocol for streams.

Reference vs. Test Site Cluster Analysis

Prior to the October 1999 canals sampling event, each station was categorized as "test" or "reference" according to expectations for its habitat and water quality conditions, based on visual observations from surrounding land use. The habitat test/reference designation was based on the frequency of management activities such as herbicide application in the immediate area. The water quality test/reference assignment was based on point and non-point discharges as well as land use upstream of the station. Figure 18 summarizes the two designations for each of the stations sampled.

The data from the October 12, 1999 sampling event were used to determine if the *apriori* expectations about the stations were justified. Cluster analyses were run

Figure 17



for several variable groupings to test these assumptions. SPlus 2000 Professional Release 3 statistical software was used to run the analyses. The agglomerative hierarchical cluster analysis method was used with Euclidean distance as a similarity measure and Ward's linkage method. The sample depth, conductivity, dissolved oxygen, pH, water temperature and turbidity values ("physical" measurements) were used in one analysis (Figure 19), and ammonia, nitrate-nitrite, TKN, TP, and algal growth potential values ("chemical" measurements)

Figure 18: Summary of water quality and habitat test or reference status by station.

Acronym	*WQ*	*Habitat*	*Station*
ref/test BM	reference	test	Billy Marsh
ref/ref BO	reference	reference	Billy Ortiz
test/ref CR	test	reference	Cadman Restored
test/test CS	test	test	Cadman Seawall
test/test CL	test	test	Carrell
ref/test F	reference	test	Fakaunion
ref/ref L	reference	reference	Lochness
test/test MP	test	test	Manual Park
ref/test ME	reference	test	Merritt
ref/test P	reference	test	Prairie
test/test SD	test	test	Seadrift
test/test SH	test	test	Shelburne
ref/ref V	reference	reference	Valkyrie

Figure 19: Physical Measurements Dendrogram
Depth,Conductivity,DO,pH,Temp,Turbidity

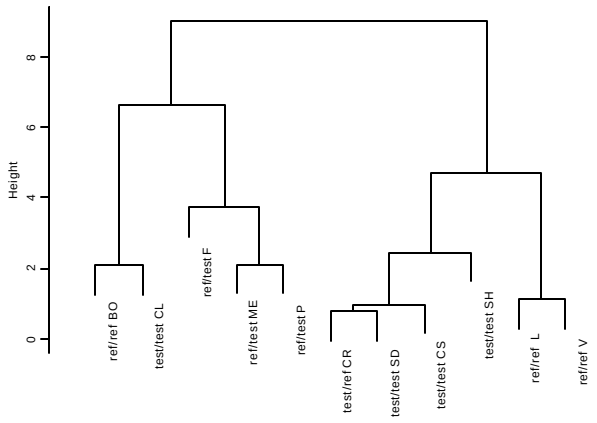
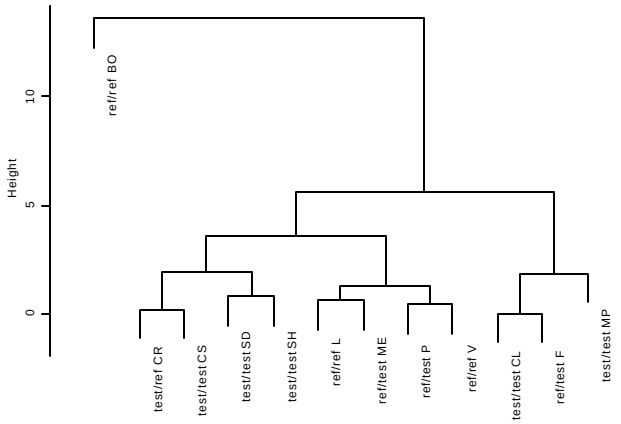


Figure 20: Chemical Measurements Dendrogram
Ammonia, Nitrate, TKN,TP,AGP



were used in a second (Figure 20). The measurements were standardized (mean of zero and standard deviation of one) prior to analysis to assure that the scale of one variable (e.g., conductivity) did not overwhelm that of another (e.g., pH). The result of a cluster analysis is a "clustering tree" or "dendrogram" that displays the similarity of the stations based on the measurements analyzed. For the most part, the water quality test/ reference designation was verified by the clusters. Stations Billy Ortiz and Fakaunion, which were initially labelled as reference sites, had very high nutrient values and clustered with the test sites.

Separate cluster analyses were run for the habitat assessment scores (Figure 21) and the SCI values (Figure 22) to verify the habitat test/reference *apriori* designations. The same clustering method was used as for the physical/chemical data, but the measurements were not standardized since these were single variable clusters. The SCI was developed for use in wadeable streams. The "cutoff" values for the SCI depend on geographic location within Florida. The "peninsula" cutoffs were used in this analysis. The habitat score dendrogram does not show good discriminating power for the original expectations since some of the "test" sites had the best habitat assessment scores. The range of values for the SCI was 17-27, a very compressed span of scores. This suggests one or both of the following:

- the SCI requires modification (different metrics or thresholds) to be able to discriminate between "test" and "reference" canals.
- our *a prio*ri classification of the systems ("reference vs. test" was inaccurate.

Figure 21: Dendrogram
Habitat Assessment Score

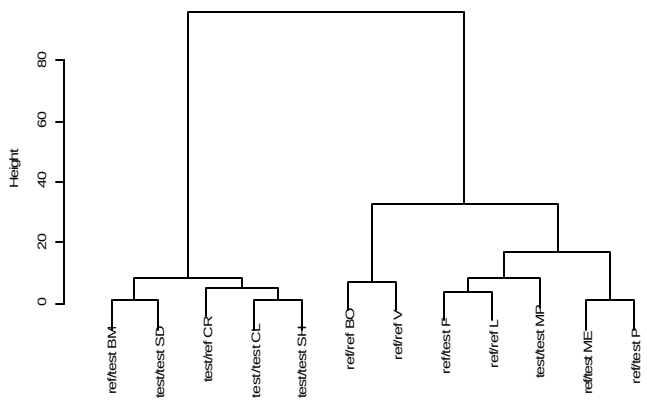
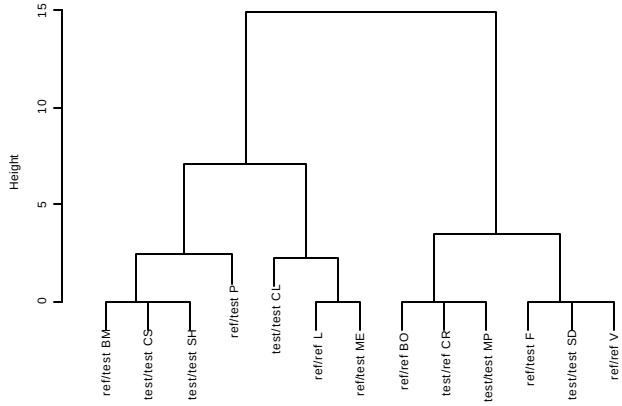


Figure 22: Dendrogram
SCI Peninsula



Conclusions

A priori evaluations of water quality and habitat categories for the canals met with mixed results. Cluster analysis demonstrated that the "test" vs. "reference" evaluations were valid for water quality nutrients (TKN, TP, ammonia, nitrate-nitrite, AGP), but not for habitat. However, no correlation between the water quality data and the SCI scores could be determined. Furthermore, comparisons of habitat reference vs. habitat test sites and SCI results from those sites showed no relationship. A relationship was observed between the SCI and habitat assessment scores between sampling events. Changes in the SCI scores followed changes in habitat assessment scores between the September/October 1999 event and the March 2000 event. Overall, habitat assessment total scores ranged from poor to low sub-optimal in all canal sites in 1999. Based on their artificial construction, canals can not be expected to span the full range of scores found in the stream habitat assessment procedures, even in expected "reference canal" habitat conditions.

Stream Condition Index (SCI) type of sampling, utilizing 20 dipnet sweeps, is currently the best available sampling tool to characterize the biological health of canal systems. Our study confirmed that 20 dipnet sweeps effectively collected approximately 70% of the available taxa in canals, with only rare taxa being added when more than 20 sweeps were collected. Furthermore, 20 sweeps could clearly distinguish high taxa richness canals (*e.g.*, Syracuse) from those with lower diversity of organisms (*e.g.*, Winkler). However, our *a prioi* approach to classifying least disturbed canals (which are all artificially created systems) was not successful. Until additional 20 dipnet sweep data is collected from an assortment of canals subject to varying degrees of human disturbance (habitat removal, water quality problems), we can not fully establish reasonable expectations for these artificial systems. Additional data would help determine which biological metrics are best suited for distinguishing between "good" and "stressed" canals. If additional canals sampling is done (sufficient to bring the total number of sites up to approximately 50) it is possible that a Canal Condition Index (CCI) could be formulated for future use. This CCI would need to consider supplementary factors, such as eco-region and flow conditions (flowing vs. stagnant) during the calibration process.

It was encouraging that many of the canals in this study actually passed the Peninsular thresholds of the SCI, indicating the resilience of the biological communities inhabiting them. However, we were not able to correlate the SCI with either water quality or visual habitat measurements, suggesting that other unobserved factors are influencing the invertebrate health of these systems.

Appendix A: Reference Wetland Stations, 1999:

Wetland Reference Stations:

Macroinvertebrate Parameters			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
STORET	CANALS020	CANALS022	CANALS021
SCI	17	15	23
Peninsula Evaluation	poor	poor	good
Number of Taxa	26	20	29
Number of Ephemeroptera	2	0	2
Number of Plecoptera	0	0	0
Number of Trichoptera	0	1	1
EPT Index	2	1	3
% Contribution Dominant Taxa	12.63	46.25	12.09
Florida Index	1	3	2
% Diptera	16.84	11.25	32.97
Total Number Chironomidae	4	5	6
% Filter-Feeders	6.32	4.38	14.84
Physical-Chemical Data			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
Avg. Sample Depth (m)		0.3	
Specific Conductivity (umho/cm)		542	
Dissolved Oxygen (mg/L)		2.4	
pH (SU)		6.8	
Temperature (deg. C)		29.6	
Turbidity (NTU)		4.2	
Nutrient data			
Station	FAKWTPRA	FAKWTPRB	FAKWTPRC
Ammonia (mg/L)		0.035	
Nitrate-Nitrite (mg/L)		0.01	
TKN (mg/L)		0.78	
Total Phosphorus (mg/L)		0.061	
AGP (mg dry wt/L)		0.4	

Appendix B: Test Wetland Stations, 1999:

Wetland Test Stations:

Macroinvertebrate Parameters			
Station	PICRMNTA	PICRMNTB	PICRMNTC
STORET	CANALS018	CANALS017	CANALS019
SCI	19	23	17
Peninsula Evaluation	poor	good	poor
Number of Taxa	28	28	24
Number of Ephemeroptera	1	1	1
Number of Plecoptera	0	0	0
Number of Trichoptera	0	1	0
EPT Index	1	2	1
% Contribution Dominant Taxa	22.88	22.02	32.71
Florida Index	1	4	1
% Diptera	53.39	43.12	40.19
Total Number Chironomidae	10	9	10
% Filter-Feeders	2.12	0	0.93
Physical-Chemical Data			
Station	PICRMNTA	PICRMNTB	PICRMNTC
Avg. Sample Depth (m)		0.1	
Specific Conductivity (umho/cm)		90	
Dissolved Oxygen (mg/L)		2.1	
pH (SU)		4.7	
Temperature (deg. C)		26.4	
Turbidity (NTU)		1.4	
Nutrient data			
Station	PICRMNTA	PICRMNTB	PICRMNTC
Ammonia (mg/L)		0.014	
Nitrate-Nitrite (mg/L)		0 BDL	
TKN (mg/L)		1.3	
Total Phosphorus (mg/L)		0.041	
AGP (mg dry wt/L)		0.4	

Appendix C: Macrophyte Taxa List for Fakahatchee Prairie Remnant A, 2000:

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

VEGETATION TRANSECT FIELD DATA (3/24/00)

Station Fakahatchee Prairie Remant A									Date 3/14/00					Comments						
Collector/Identifier	Riley,Richardson,Boler																			
Taxa on Transect	**0-5 m**	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**35-40**	**40-45**	**45-50**	**50-55**	**55-60**	**60-65**	**65-70**	**70-75**	**75-80**	**80-85**	**85-90**	**90-95**	**95-100**
Cladium jamaicense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mikania scanadense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Proserpinaca palustris	x	x	x	x		x		x	x	x		x			x	x	x	x	x	
Erigeron quercifolia	x											x					x			
Lycopus rubellus (Unknown 1)	x	x		x	x	x	x	x		x	x		x	x	x	x	x	x	x	x
Eupatorium mikanoides (Unkn	x	x	x	x		x	x	x			x		x		x					x
Crinum americanum	x	x	x	x	x		x	x	x	x		x	x		x	x	x			x
Ipomoea sp.	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Solidago sp. 1	x		x	x	x		x		x					x		x		x	x	
Centella asiatica (Unknown 9)		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x
Ludwigia repens		x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x
Lamiaceae		x																		x
Eupatorium sp. (Unknown 5)		x												x						
Solidago sp. 2		x	x	x				x			x								x	x
Juncus sp.			x	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x
Lobelia glandulosa			x										x				x	x		x
Panicum sp. 1				x		x												x		
Baccharis				x	x	x	x	x		x							x			
Sagittaria sp.					x		x			x		x	x		x			x		x
Eupatorium sp. (Unknown 15)					x															
Ludwigia peruviana						x				x	x		x		x	x			x	
Boehmeria cylindrica						x		x										x		
Polygala grandiflora (Unknown 17)						x		x												x
Dryopteris ludoviciana						x														
Dichromena colorata							x									x				
Sagittaria graminea							x	x				x					x	x	x	x
Rhyncospora decurrens									x					x	x					
Rhyncospora inundata											x									x
Hypericum sp.																x	x	x		
Erianthus giganteus																x		x	x	
Cyperus sp.																		x		
Unknown 16 (corkwood)																		x	x	

Appendix D: Macrophyte Taxa List for Fakahatchee Prairie Remnant B, 2000:

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

VEGETATION TRANSECT FIELD DATA (3/24/00)

Station Fakahatchee Prairie Remnant B | Date 3/14/00 | Comments

Collector/Identifier Frick, Bennett, Karen

Taxa on Transect	0-5 m	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Cladium jamaicense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ludwigia peruviana	x												x	x				x		
Mikania scanadense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Proserpinaca palustris	x	x	x	x	x	x			x	x		x	x	x	x	x	x	x		x
Sarcostemum clausum	x																			
Hyptis alata		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Centella asiatica (Unknown 9)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Juncus sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Crinum americanum		x		x	x	x	x	x	x	x	x	x	x	x	x		x		x	
Unknown 14 (hairy)		x				x														
Cirsium horridulum		x	x										x							
Ipomoea sp.		x	x		x		x	x	x	x	x	x		x	x			x	x	
Teucrium sp.		x																		
Pluchea sp.		x		x																
Erianthus giganteus			x			x		x			x		x	x	x	x	x	x		x
Rhyncospora inundata			x	x		x		x	x	x		x	x	x	x	x	x	x	x	
Eupatorium sp. (Unknown15)			x	x															x	
Stillingia sylvatica (Unknown 16)			x																	
Ludwigia repens			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bacopa caroliniana				x	x															x
Saggitaria graminea				x					x	x		x	x	x	x	x	x	x	x	x
Saggitaria lancifolia					x	x	x				x	x	x	x		x	x	x		x
Sideroxylon reclinatum							x													
Erigeron quercifolia							x	x						x			x			
Eupatorium sp. (Unknown 5)							x													
Erigeron quercifolius (Unknown 18)								x		x							x			
Lycopus rubellus (Unknown 1)								x												
Panicum sp.																		x		x
Baccharis sp.															x			x	x	
Bacopa monnieri (Unknown 19)											x				x					
Polygala grandiflora (Unknown 17)										x	x				x		x			
Solidago sp.									x						x					x
Salix caroliniana									x											
Ilex casine								x												
Hypericum sp.													x							

Appendix E: Macrophyte Taxa List for Picayune Remnant A, 2000:

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

VEGETATION TRANSECT FIELD DATA (3/24/00)

Station	Picayune Remnant A	Date	3/14/00	Comments
Collector/Identifier	Frick, Riley, Richardson			

Taxa on Transect	0-5 m	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Cephalanthus occidentalis	x	x								x			x	x	x	x		x		
Hypericum fasiculatum	x							x	x	x				x		x				
Mikania scanadense	x	x	x				x		x	x	x	x	x	x					x	
Pontaderia cordata	x		x					x		x	x	x	x	x	x					
Panicum (small seed head)	x	x												x			x		x	
Ludwigia hertella	x																			
Ipomoea	x																			
Sarcostemum clausum	x	x	x	x	x	x		x								x			x	
Hyptis alata	x	x																		
Teucrium canadense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Cladium jamaicense																		x	x	x
Acer rubrum	x	x		x			x	x						x	x					
Blechnum serrulatum	x	x	x			x	x	x	x	x	x	x		x	x	x	x	x	x	x
Ampelopsis arborea	x	x	x	x			x	x								x	x	x	x	x
Lycopus rubellus (Unknown 1)	x																			
Eupatorium capillifolium (Unknown		x					x													x
Pityopsis graminifolia (Unknown 3)		x					x													
Unknown 4		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	
Vitas rotundifolia (spell?)			x						x											
Thelypteris dentata			x	x	x				x	x	x	x	x							
Rhynchospora inundata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Eupatorium sp. (Unknown 5)					x	x	x	x	x		x		x	x	x		x	x		x
Erianthus giganteus					x	x	x			x	x									
Baccharis sp.						x	x	x	x			x	x		x					x
Oenothera sp. (Unknown 6)					x	x														
Erigeron quercifolia						x						x	x	x		x	x	x	x	x
Eupitorium capillifolium						x			x	x		x	x	x	x	x	x	x	x	x
Carex verrucosa						x	x	x	x				x		x					
Eupatorium mikanoides (Unknown 8)								x							x	x	x	x	x	
Centella asiatica (Unknown 9)																	x	x		
Sideroxylon reclinatum									x		x									
Ludwigia peruviana										x	x	x								
Saggitaria lancifolia													x	x		x				
Boehmeria cylindrica													x			x				
Melaleuca quinquenervia																x	x	x	x	
Juncus marginatus (Unknown 10)																		x		
"Sweet Pea" (small pink flower)																			x	
Rubus trivialis															x		x			
Eupitorium mikanoides								x	x					x	x					

Appendix F: Macrophyte Taxa List for Picayune Remnant B, 2000:

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

VEGETATION TRANSECT FIELD DATA (3/24/00)

Station Picayune Strand Remnant B | Date 3/14/00 | Comments

Collector/Identifier Frick, Riley, Richardson

Taxa on Transect	0-5 m	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Hyptis elata	x	x	x													x	x			
Teucrium canadense	x	x	x	x	x	x		x	x	x					x					
Sarcostemum clausum	x	x				x	x		x	x	x		x							
Acer rubrum	x	x	x																	
Rhynchospora inundata	x	x	x	x	x	x	x	x	x	x	x			x	x		x		x	x
Eupatorium sp. (Unknown 5)	x	x			x	x	x	x	x	x	x		x	x	x	x	x		x	
Hypericum sp.	x	x		x								x			x	x	x	x		x
Panicum sp. 1	x	x	x		x	x		x	x	x	x		x	x			x			
Mikania scanadense	x	x	x	x		x		x				x								
Centella asiatica (Unknown 9)	x	x	x		x	x						x	x		x	x				
Erigeron quercifolia	x				x	x	x		x	x	x		x	x	x	x	x		x	x
Proserpinaca palustris	x			x	x		x										x			
Lycopus rubellus (Unknown 1)	x								x	x	x	x	x	x	x			x		x
Eupatorium mikanoides (Unkn	x	x	x	x		x		x										x		
Unknown 4		x	x	x	x					x										
Eupatorium capillifolium (Unknown 2)			x	x																
Polygala grandiflora (Unknown 11)		x																		
Cladium jamaicense		x													x		x		x	x
Carex lupiformis		x																		
Blechnum serrulatum		x	x				x				x	x							x	
Pontederia cordata		x			x	x	x		x	x	x	x	x	x	x					x
Polygonum densiflorum		x																		
Cyperus haspan		x																		
Kosteletzkya virginica (Unknown 12)			x																	
Erianthus giganteus			x	x	x		x	x	x		x		x	x	x	x	x			x
Rhus radicans			x																	
Euportium capillifolium			x		x		x			x	x			x	x	x		x	x	
Pityopsis grminifolia (Unknown 3)			x																	
Ludwigia peruviana			x																	
Boehmeria cylindrica						x														
Ludwigia sp. (hertella?)				x	x		x													
Ludwigia repens				x	x	x								x					x	
Eupatorium mikanoides					x	x							x							
Cephalanthus occidentalis					x								x					x		
Ampelopsis arborea							x	x	x											

Appendix G: Manuals Branch at U.S. 41:

		Number of Individuals Counted							
Taxon	*Sweep set where taxon first appears*	*Sweep Set 1 (each set is 5 sweeps)*	*Sweep Set 2*	*Sweep Set 3*	*Sweep Set 4*	*Sweep Set 5*	*Sweep Set 6*	*Sweep Set 7*	*Sweep Set 8*
Ablabesmyia rhamphe grp.	Added in 5					2			
Amnicola dalli johnsoni	Added in 1	2							
Ancylidae	Added in 1	13	1	2		1	1		
Argia	Added in 2		1	1				2	
Argia sedula	Added in 1	2			3			1	
Asheum beckae	Added in 1	1							
Astacidae	Added in 6						1		
Belostoma	Added in 8								1
Bratislavia unidentata	Added in 1	2	2						
Caenis	Added in 1	1				1		1	
Callibaetis	Added in 1	1							
Cambaridae	Added in 1	2		1		3			
Chironomidae	Added in 1	2	5	2	1	1	1		
Coenagrionidae	Added in 1	2			2	2		1	
Cricotopus bicinctus grp.	Added in 2		4			3			10
Decapoda	Added in 5					2			
Dero digitata	Added in 1	8			3	1			
Dero pectinata	Added in 1	3							
Dicrotendipes neomodestus	Added in 6						1	1	
Enallagma	Added in 1	3		1					
Enchytraeidae	Added in 2		1						
Erpobdellidae	Added in 1	1							
Erythemis	Added in 1	1		1					
Erythemis simplicicollis	Added in 4				1				
Gastropoda	Added in 2		1		3	1		1	1
Gloiobdella elongata	Added in 1	1			1	3			
Glyptotendipes	Added in 6						1	1	
Haber speciosus	Added in 4				1				
Hebetancylus excentricus	Added in 2		1						
Helobdella stagnalis	Added in 1	1				1			
Helobdella triserialis	Added in 1	1							
Hirudinea	Added in 1	2							1
Hydrobiidae	Added in 8								1
Ischnura	Added in 2		2						
Laevapex peninsulae	Added in 6						1		
Larsia	Added in 8								1
Larsia decolorata	Added in 1	4							
Libellulidae	Added in 1	6			3				
Limnodrilus hoffmeisteri	Added in 2		5		1	6	3	3	
Lioplax	Added in 6						1		
Marisa cornuarietis	Added in 8								1
Melanoides tuberculata	Added in 1	25	13	12	6	10	14	39	21
Mooreobdella	Added in 8								1
Naididae	Added in 2		1						
Noteridae	Added in 1	1							
Odonata	Added in 6						1	1	
Oxyethira	Added in 2		2	2		2	4		1
Peltodytes	Added in 2		1		2				2
Planorbella	Added in 5					1			
Polypedilum halterale grp.	Added in 4				1				
Polypedilum illinoense grp.	Added in 1	2	3			2	2	2	2
Pomacea paludosa	Added in 3			1		1			
Pristina	Added in 6						1	1	
Pristina aequiseta	Added in 1	2							
Pristina synclites	Added in 2		1						
Pristinella jenkinae	Added in 1	1							
Procambarus	Added in 6						1		
Prostoma rubrum	Added in 1	2	1						
Pyrogophorus platyrachis	Added in 7							1	1
Sphaeriidae(mollusca)	Added in 1	26	8	6	4	14	2	2	8
Thiaridae	Added in 7							1	
Turbellaria	Added in 6						1		
Total taxa in replicate		28	18	10	14	19	16	15	14
Number of new taxa added		28	11	1	3	3	9	2	5

Appendix H: Syracuse above Douglas Rd.:

		Number of Individuals Counted							
Taxon	*Sweep set where taxon first appears*	*Sweep Set 1 (each set is 5 sweeps)*	*Sweep Set 2*	*Sweep Set 3*	*Sweep Set 4*	*Sweep Set 5*	*Sweep Set 6*	*Sweep Set 7*	*Sweep Set 8*
Ablabesmyia rhamphe grp.	Added in 4				1			1	
Allonais paraguayensis	Added in 5					2	1	1	1
Ancylidae	Added in 1	1			3				
Arrenurus	Added in 1	1	8	6	5	1		1	5
Arrenurus zorus	Added in 3			1					
Asheum beckae	Added in 2		3		2		1		
Aulodrilus pigueti	Added in 3			1					
Beardius truncatus	Added in 1	4	5	4	7	9	18		8
Belostoma	Added in 2		1			1			
Bidessonotus	Added in 4				1				
Bratislavia unidentata	Added in 2		1			1	2		2
Callibaetis	Added in 1	1							
Callibaetis floridanus	Added in 2		4	4		3	3	1	5
Cecidomyiidae	Added in 4				1				
Ceratopogonidae	Added in 2		1	1					1
Chironomidae	Added in 1	2	4	3	1	4	4	5	7
Cladopelma	Added in 2		1						
Clinohelea	Added in 6						3		
Coenagrionidae	Added in 1	3							4
Corduliidae	Added in 3			1				2	
Cricotopus bicinctus grp.	Added in 2		1						
Culicidae	Added in 5					1			
Curculionidae	Added in 4				1	1			
Dasyhelea	Added in 2		5		1	1			4
Decapoda	Added in 2		5			2		1	
Dero digitata	Added in 1	1				1		5	
Dero digitata complex	Added in 2		2	1			4		
Dero pectinata	Added in 2		2		4	10	26	3	14
Dicrotendipes	Added in 4				2				
Dicrotendipes modestus	Added in 2		1			2			1
Donacia	Added in 3			1					
Dytiscidae	Added in 7							1	
Elmidae	Added in 7							1	
Enallagma	Added in 2		1	5	4		1		2
Enchytraeidae	Added in 7							1	
Endochironomus nigricans	Added in 2		1	1					
Erythemis simplicicollis	Added in 4				9				2
Eupera cubensis	Added in 1	1			2		25	16	2
Fittkauimyia serta	Added in 4				1				
Gastropoda	Added in 1	1				1	2		
Gerridae	Added in 5					3			
Glyptotendipes	Added in 1	1	2				11	3	9
Goeldichironomus	Added in 6						1		
Haemonais waldvogeli	Added in 2		1					1	
Hebetancylus excentricus	Added in 8								1
Hebridae	Added in 5					4			
Hebrus	Added in 4				9				
Heteroptera	Added in 8								4
Hyalella azteca	Added in 1	7	60	11	28	6	4	1	15
Hydraena marginicollis	Added in 4				1				
Hydrodroma	Added in 1	1	5		2	1	2	1	4
Hydrophilidae	Added in 8								1
Hydrovatus	Added in 7							1	
Ischnura	Added in 4				1				
Krendowskia	Added in 1	1	1						1
Labrundinia	Added in 7							1	
Labrundinia johannseni	Added in 4				1				
Labrundinia sp. 4 epler	Added in 4				3				
Larsia decolorata	Added in 1	1	14	1	12	19	10	18	15
Lebertia	Added in 6						1		
Lepidoptera	Added in 1	1							
Libellula semifasciata	Added in 6						1		

Libellulidae	Added in 1	1				4	1		2
Limnesia	Added in 2		1						
Limonia	Added in 8								3
Liodessus	Added in 8								1
Littoridinops monroensis	Added in 7							1	
Labrundinia sp. 4 epler	Added in 4				21				
Micromenetus floridensis	Added in 2		1	1					1
Microvelia	Added in 3			1					9
Munroessa	Added in 4				3				
Naididae	Added in 1	1							
Nais communis	Added in 7							4	
Nanocladius	Added in 2		1	2					1
Neumania	Added in 1	1	2		1	1			4
Nilothauma	Added in 2		1	1					1
Odonata	Added in 2		2			1	1	1	2
Odontomyia	Added in 2		1			3		1	4
Oecetis	Added in 3			1					
Oribatei	Added in 1	2				8	18	36	22
Orthotrichia	Added in 1	1		1		2	2		2
Oxyethira	Added in 3			2					
Palaemonetes	Added in 1	3							
Palaemonetes paludosus	Added in 3			4	4	3		1	8
Palpomyia/bezzia grp.	Added in 8								1
Parachironomus	Added in 3			1					
Parachironomus carinatus	Added in 6						2	1	
Parakiefferiella sp. c epler	Added in 8								1
Paratanytarsus sp. c epler	Added in 2		1			3			1
Pelocoris	Added in 8								1
Physella	Added in 1	3	3	5	18	2	2		3
Piona	Added in 5					1			
Planaria	Added in 2		4	3			6		9
Planariidae	Added in 1	9			3	1		6	
Planorbella	Added in 1	1	1		10	1			1
Planorbidae	Added in 5					1			
Polycentropodidae	Added in 1	1					2		
Polycentropus	Added in 2		5		1				
Polypedilum illinoense grp.	Added in 5					2	3		
Polypedilum trigonum	Added in 1	3	4	1	1	6		2	16
Pomacea paludosa	Added in 1	1	2				1		
Pristina	Added in 5					2			1
Pristina aequiseta	Added in 4				1	14	6	6	6
Pristina leidyi	Added in 4				2	9			
Pristinella	Added in 4				1				
Pseudochironomus	Added in 1	1	12		1	2	3	6	2
Pseudochironomus richardson	Added in 3			1	2				
Pyralidae	Added in 2		1	1					1
Pyrogophorus platyrachis	Added in 2		1				1		3
Slavina appendiculata	Added in 6						2	2	
Stratiomyidae	Added in 4				1				
Synaptonecta issa	Added in 4				1				
Synclita	Added in 4				1				
Tanytarsus	Added in 1	2				1	4	3	5
Tanytarsus sp. c epler	Added in 2		15	2	10	20	10	4	18
Tanytarsus sp. e epler	Added in 4				1	1			
Tanytarsus sp. f epler	Added in 4				1				
Tanytarsus sp. g epler	Added in 7							5	2
Tanytarsus sp. j epler	Added in 5					6			
Tanytarsus sp. l epler	Added in 8								1
Tanytarsus sp. r epler	Added in 2		1						2
Tanytarsus sp. t epler	Added in 1	1	1	1			5		
Trepobates	Added in 4				1				
Trichoptera	Added in 6						1		1
Unionicola	Added in 1	2				2		3	1
Veliidae	Added in 6						1		
Zavreliella marmorata	Added in 7							2	
Zygoptera	Added in 5					1	1	1	
Total taxa in replicate		31	44	30	44	45	40	38	56
Number of new taxa added		31	29	10	22	10	8	9	9

Appendix I: Winkler above Princeton:

		Number of Individuals Counted							
Taxon	*Sweep set where taxon first appears*	*Sweep Set 1 (each set is 5 sweeps)*	*Sweep Set 2*	*Sweep Set 3*	*Sweep Set 4*	*Sweep Set 5*	*Sweep Set 6*	*Sweep Set 7*	*Sweep Set 8*
Ancylidae	added in 2		1					4	1
Asheum beckae	added in 2		1						
Aulodrilus pigueti	added in 4				1			1	
Berosus	added in 5					1		1	
Callibaetis	added in 3			1					
Callibaetis floridanus	added in 1	2				1	2	3	
Ceratopogonidae	added in 7							1	
Chironomidae	added in 7							4	2
Cladopelma	added in 3			1			1		1
Coenagrionidae	added in 4				1	1			1
Culicoides	added in 8								1
Dero digitata	added in 2		1					1	
Dero digitata complex	added in 3			10	4	2			
Dero pectinata	added in 5					3	1	2	1
Elimia	added in 5					1			
Ferrissia hendersoni	added in 7							1	
Gastropoda	added in 4				9			1	
Goeldichironomus	added in 7							2	3
Goeldichironomus holoprasinus	added in 2		1	3				3	
Goeldichironomus natans	added in 1	5	2			3	1	1	
Haemonais waldvogeli	added in 4				1				
Hyalella azteca	added in 1	1	2	1	10	6	2	9	1
Hydrobiidae	added in 1	4				1			
Labrundinia sp. b epler	added in 4				1				
Laevapex	added in 3			2					
Larsia	added in 4				1				
Larsia decolorata	added in 4				2			1	
Libellulidae	added in 1	1							
Limnodrilus hoffmeisteri	added in 1	9	4		1	2	2	6	16
Marisa cornuarietis	added in 3			1				1	
Melanoides tuberculata	added in 1	3	1	1				2	1
Micromenetus dilatatus avus	added in 1	4		1					
Microvelia	added in 1	1							
Odontomyia	added in 2		1	1	1	1		1	
Oribatei	added in 1	1	1						
Palaemonetes	added in 2		1					1	
Palaemonidae	added in 8								1
Parachironomus directus	added in 2		1		2	3	6	1	2
Peltodytes	added in 6						1		
Peltodytes dietrichi	added in 1	1				1			
Peltodytes muticus	added in 8								3
Physella	added in 6						1		
Polypedilum trigonum	added in 2		1						
Pristina	added in 2		1						
Pristina aequiseta	added in 7							1	
Pristina leidyi	added in 2		1						
Procambarus	added in 6						1		
Pyralidae	added in 7							1	
Pyrogophorus platyrachis	added in 1	1		4	9		2	1	
Trombidiformes	added in 6						1		
Total taxa in replicate		12	15	11	13	13	12	24	13
Number of new taxa added		12	10	5	7	3	4	6	3